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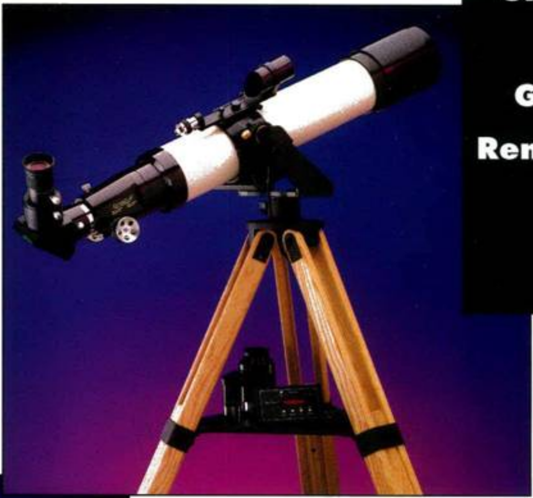

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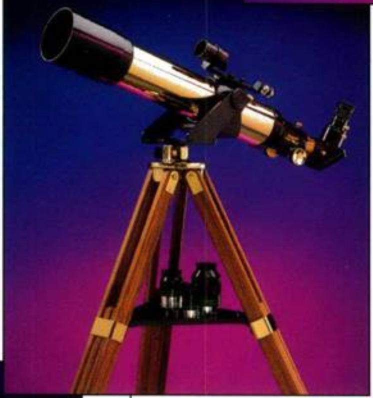

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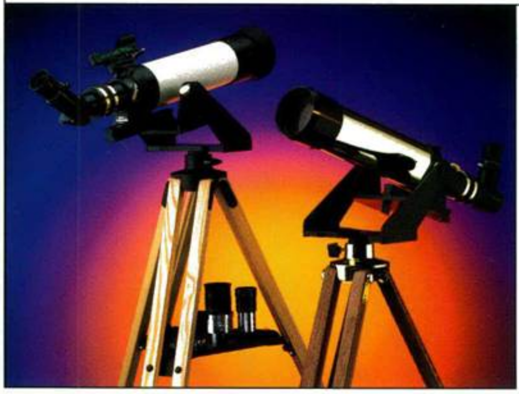

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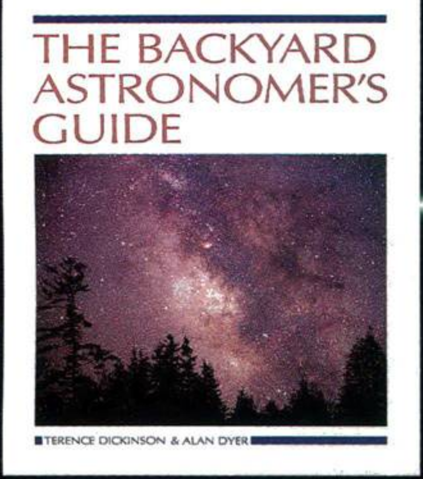
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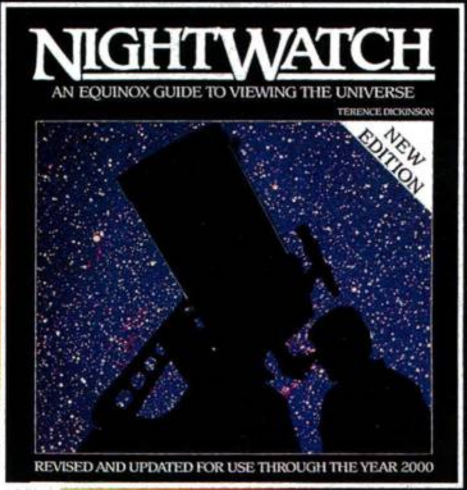
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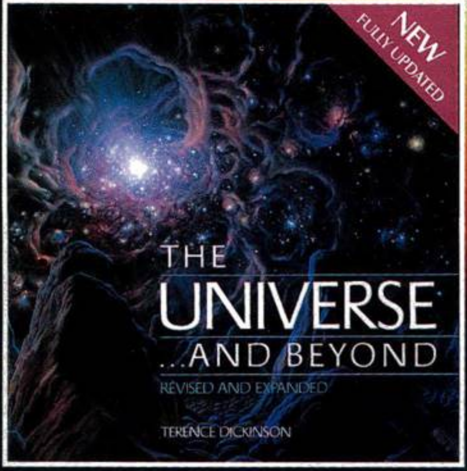
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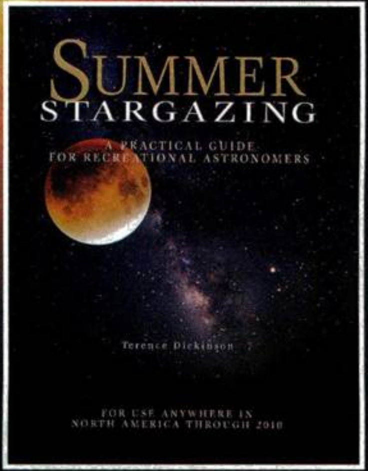
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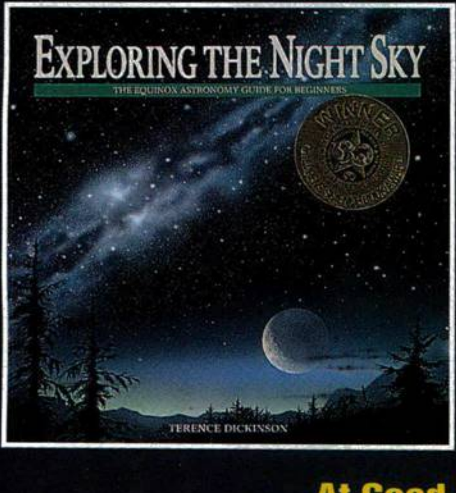
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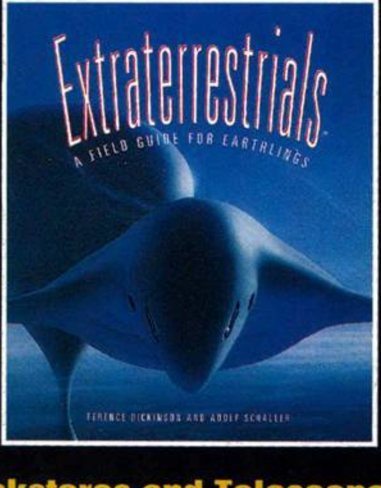
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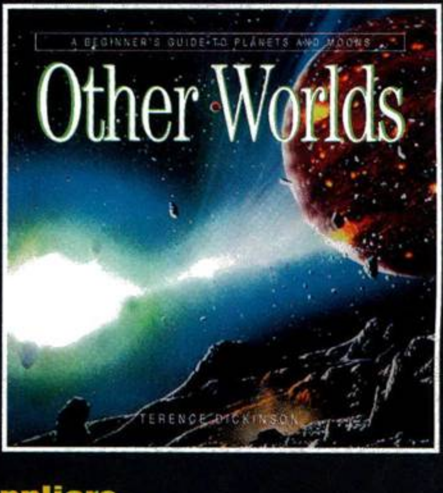
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# EXPLORE THE UNIVERSE

3RD EDITION 1997

Steve Foster and B. Frank Hinson

98 The Beautiful Universe

## COVER STORY

### 62

### Comet Hale-Bopp Arrives

After months of gradual brightening, the comet of the decade stages a spectacular show this spring. This astronomical treat arrives as we look back on last year's great comet, Hyakutake. Photo of Comet Hyakutake by Bob and Janice Fera.

## FEATURES

### 8 Discover the Backyard Universe

*Glenn F. Chaple, Jr.*

A whole universe of exploration awaits amateur astronomers on every clear night. All it takes to get started is curiosity, a pair of binoculars, and this sweeping overview of the stars, planets, and galaxies.

### 49 ASTRONOMY's 1997 Skyguide

*Jeff Kanipe, Richard Talcott, John Shibley, and Patti Kurtz*

The world's leading astronomy magazine brings you every significant sky event of the coming year — meteor showers, eclipses, comets, the Moon, the golden rings of Saturn, dusky surface of Mars, and belts of Jupiter.

- 62 Comet Hale-Bopp Arrives
- 64 The Moon From Your Backyard
- 66 The Stars Season by Season

Jean Dragesco

49 ASTRONOMY's 1997 Skyguide

Tim Hunter and James McGaha

8 Discover the Backyard Universe

George Greaney

74 Exploring the Virtual Universe

Jerry Schad

84 Capture the Sky on Film

## 74 Exploring the Virtual Universe

*David Bruning*

Cloudy weather tonight? A virtual universe awaits inside your PC or Powermac. Connect to what's happening in astronomy on the Internet or sample the expanding world of astronomy CD-ROMs.

## 84 Capture the Sky on Film

*Alan Dyer*

Collect your own portraits of the universe. It's as simple as loading your camera with fast color film, choosing some targets, setting it on a tripod, and opening the shutter.

## 98 The Beautiful Universe

The greatest astro-images of 1995–1996 celebrate the beauty of Comet Hyakutake, the rich splendor of the summer Milky Way, and much more.

## DEPARTMENTS

### 6 At the Eyepiece

Let's Get Together and Self-Actualize

### 6 Contributors

Get to know us! Meet the authors of *Explore the Universe 1997.*

### 93 Advertiser Index

# AT THE EYEPIECE

## Let's Get Together and Self-Actualize

A philosopher once recorded that more than 99 percent of all humans who ever lived on Earth failed to place themselves in the context of the cosmos. They were born, educated, found love, employment, lived through sickness and health, and finally died, all without understanding the unbelievably huge and complex nature of the solar system that surrounds Earth, the Galaxy that surrounds the solar system, and the universe that surrounds the Galaxy.

That's what the hobby of astronomy is all about — that moment of discovery when, in some dark field at the eyepiece of a telescope, your first view of the Moon, Saturn, or a distant galaxy resets your comprehension of everything — remakes your world view. Psychologists call it a "moment of self-actualization." Backyard astronomers simply call it having a good time exploring the depths of the vast cosmos beyond our familiar, everyday world.

Such a laboratory as the universe comes freely available. On any dark night, away from city lights, it returns. A pair of binoculars reveals the vast star clouds of the Milky Way. Small telescopes reveal details on the globes of the planets, hundreds of lunar craters, and 10,000 galaxies, star clusters, and gas clouds in our Galaxy.

Whether you are new to astronomy or are returning to rediscover its joys, I invite you to explore the universe in these pages and let it help you enjoy the more vast universe above your head.

Sincerely,

Dave Eicher
Editor

## Contributors

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***Glenn F. Chaple, Jr.*** is a teacher living in Townsend, Massachusetts. A frequent contributor to ASTRONOMY and *Odyssey* magazines, he is coauthor of the *Edmund Mag. 6 Star Atlas.*

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***Rich Talcott*** is an associate editor of ASTRONOMY. He finds the eerie beauty of solar eclipses particularly interesting, and is coauthor of *Chasing the Shadow: An Observer's Guide to Eclipses.*

EXPLORE THE UNIVERSE
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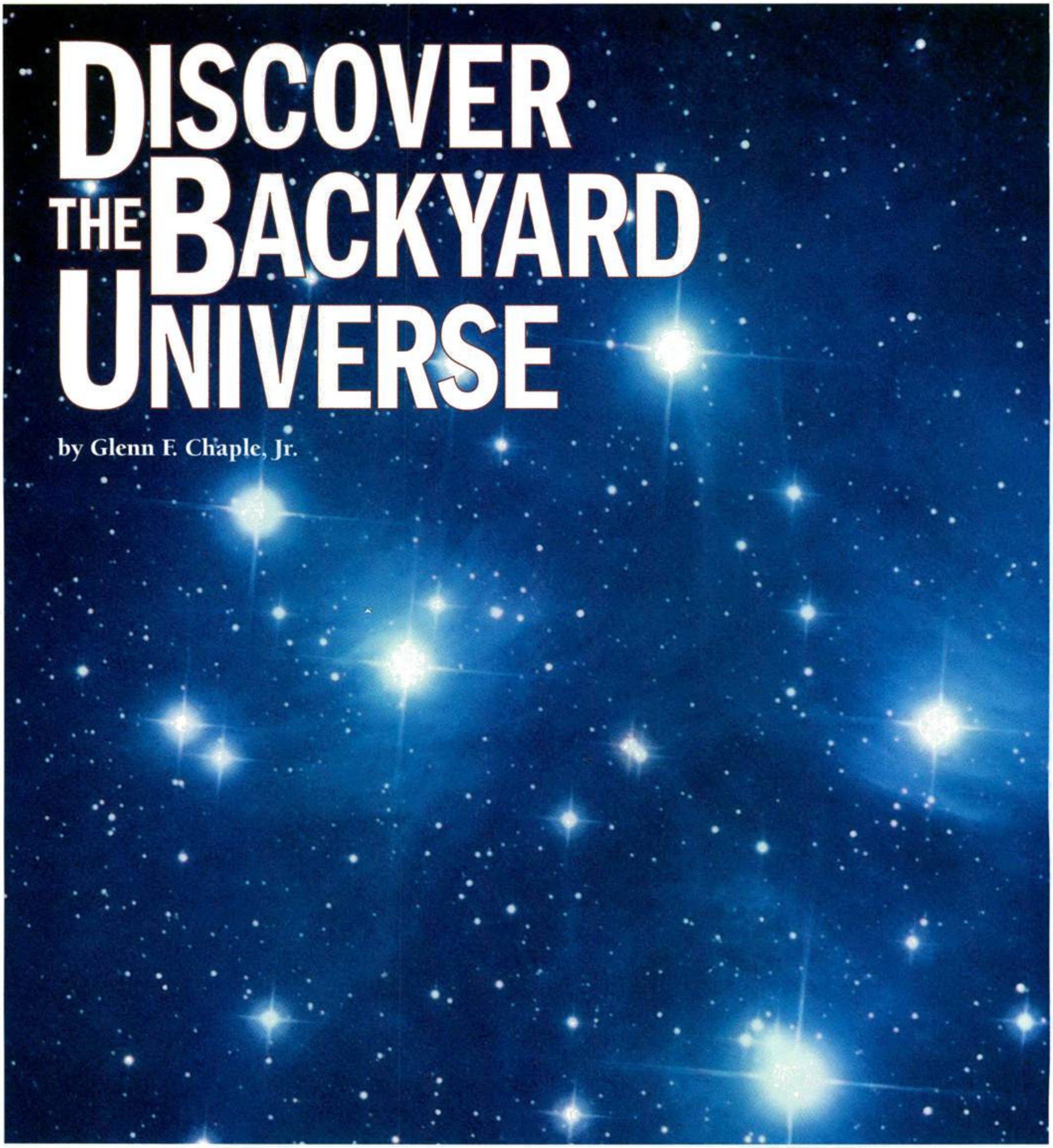
# DISCOVER THE BACKYARD UNIVERSE

by Glenn F. Chaple, Jr.



Bill and Sally Fletcher

**The Pleiades Star Cluster**

## Step into the Cosmos

Imagine yourself outside on a clear evening early this September. The Sun has set, filling the western sky with a salmon pink glow that blends to a deep blue overhead. A crescent Moon pierces the sunset glow, much sharper in outline than it was during those hazy evenings of early summer. Although alone, you sense the presence of those thousands of individuals whose eyes, at this very moment, must also be riveted to this silvery magnet.

Do these casual stargazers notice a brilliant evening star below the Moon? Most who do are probably unaware that the "star" is really our sister planet, Venus. A real star, Spica, glimmering faintly beneath Venus, completes a cosmic triangle. East of this trio is Mars, a ghost of what it was when it was at opposition earlier this year. Knowing that tonight's skies harbor yet another of the Sun's family, you turn eastward to greet mighty Jupiter. Not as bright as Venus, it is still an imposing sight in this much-darker region of the sky. For a moment, you gaze to Earth at

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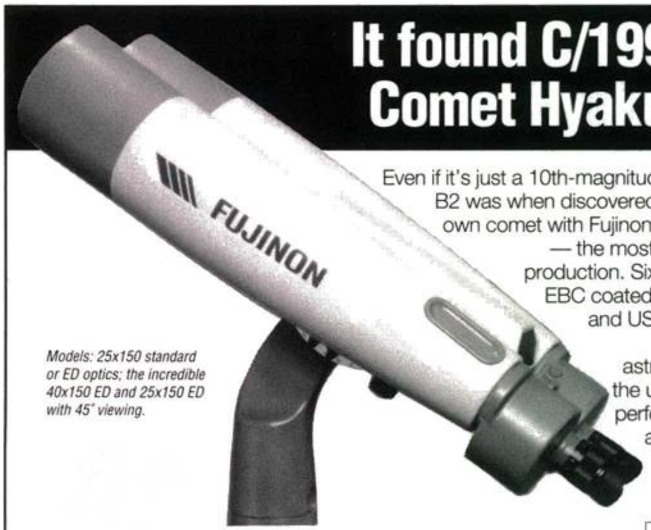
## It found C/1996 B2, Comet Hyakutake



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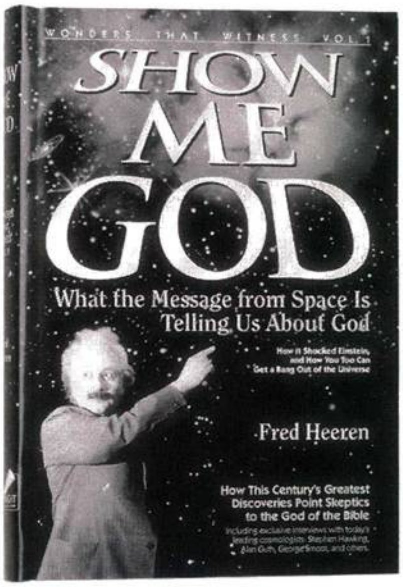
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Mark Erickson

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your feet, then at Venus, Mars, and Jupiter. Four planets with a single sweep of the eye.

Out of the corner of your eye you glimpse a streak of light as a "shooting star" zips across the northeast sky. One of the solar system's tiniest denizens has met its fiery death. You've always thought of meteors as surprise gifts nature bestows upon those who take the time to admire her handiwork.

The skies have darkened, and the stars of late summer are coming into view. Above the Moon is Arcturus; higher still, the Big Dipper, whose handle forms the arc that leads to Arcturus. The golden yellow color of Arcturus pales in comparison to the ruddy hue of Antares, shining balefully in the southern sky. The Rival of Mars lives up to its name tonight. Overhead, the Summer Triangle — Deneb, Vega, and Altair — shines down on you as it has for more summers than you can remember.

Deneb and its parent constellation Cygnus are immersed in a rich river of misty light that arches across the sky — the Milky Way. As you stand alone under this timeless and endless canopy, you begin to sense your place in it. You can almost feel Earth's rotation and sense that relentless easterly drift of the Moon and planets against the background stars. Even the stars seem in motion — a part of that vast merry-go-round that is our Galaxy. In mind and spirit, you have become a part of this vast cosmic drama. Welcome to the universe.

The night sky is our window on a universe as beautiful as it is mysterious. Astronomers tell us that it's a limited window — our eyes detect a mere trickle of the river of energy that comes from space. Nevertheless, a view of the heavens with the unaided eye, especially during summer when the Milky Way arches across the sky, is one of nature's most inspiring sights.

A tour of the universe doesn't require a telescope. Even binoculars, for that matter. Your eyes can can actually see a lot that optical tools

David Harris

**Aurora and the Big Dipper**

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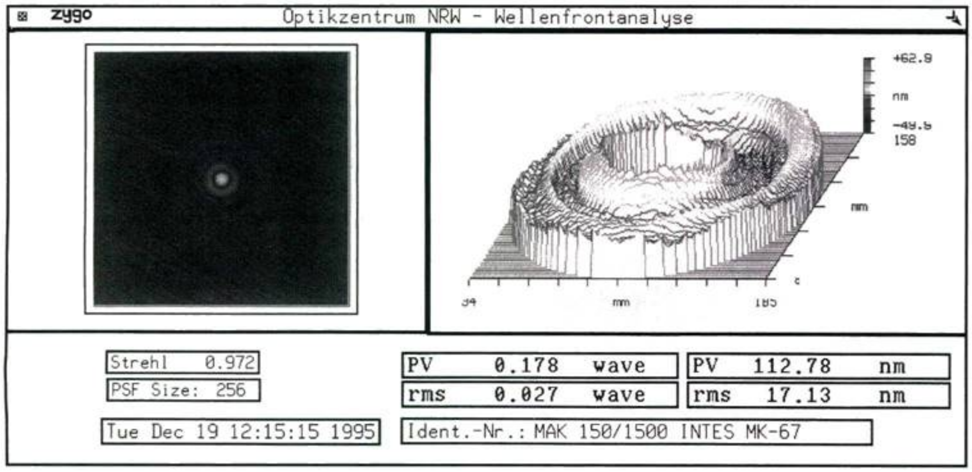

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Strehl 0.972
PSF Size: 256
Tue Dec 19 12:15:15 1995

PV 0.178 wave
rms 0.027 wave

PV 112.78 nm
rms 17.13 nm

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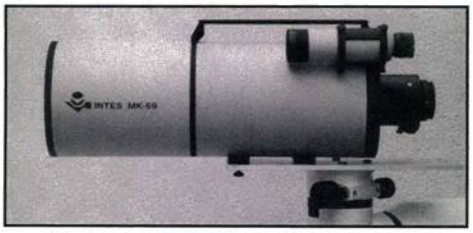

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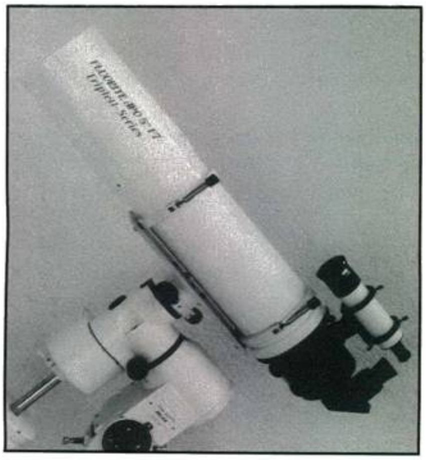

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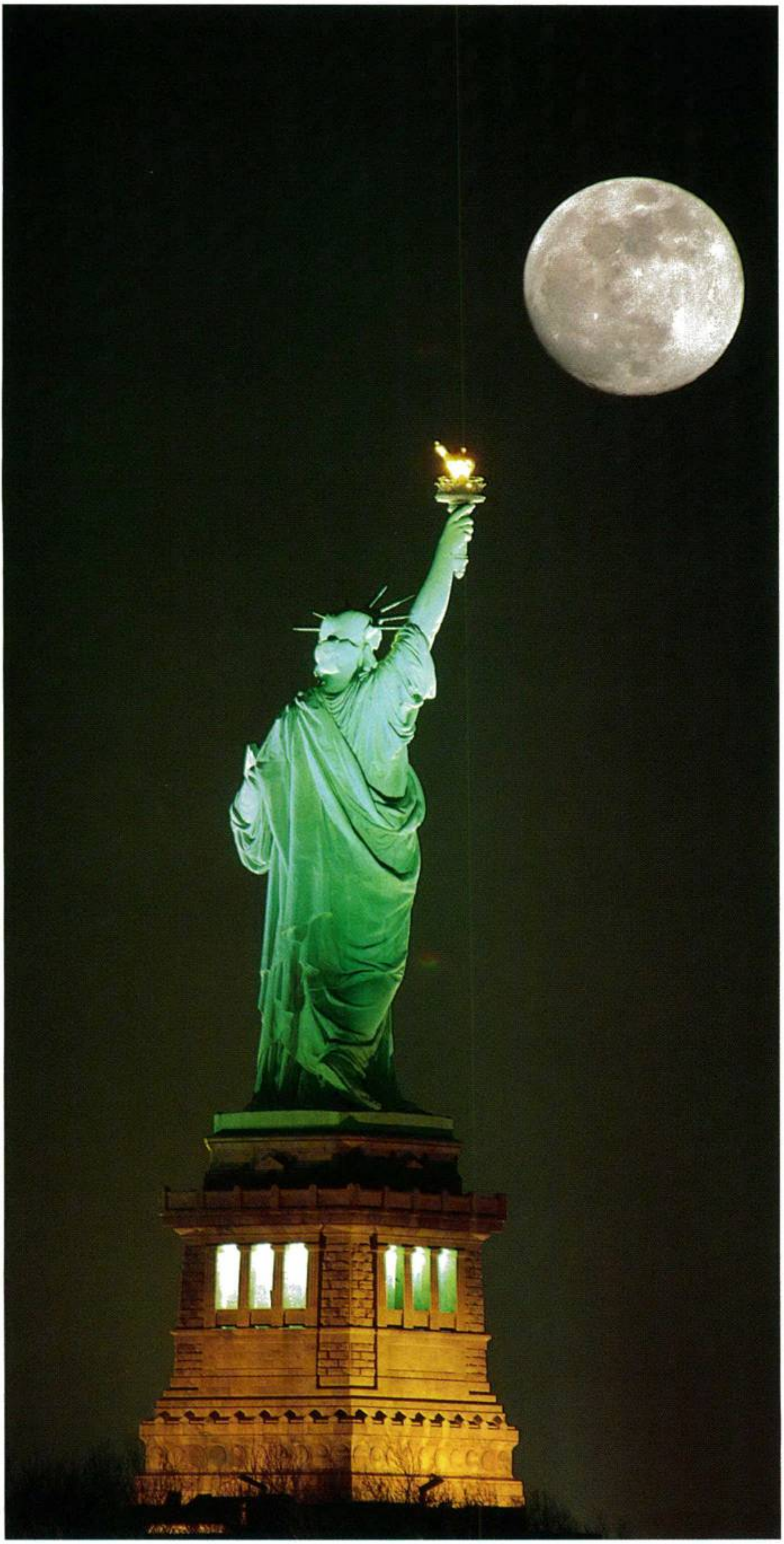

Larry Landolfi

Moonrise over the Statue of Liberty

miss. Here is a rundown of some sights and events that can be enjoyed with the unaided eye in 1997. Whether you're a beginner or a seasoned veteran looking to get back to your roots, give them a try.

## The Sun

Long before the advent of calendars and timepieces, our ancestors used the movements of the Sun to mark the passage of time. Like these ancient skygazers, you can watch the cycles of the Sun — its daily rising and setting, and the seasonal changes in the location of sunrise and sunset.

The Sun, along with Earth's magnetic field, creates that strangely beautiful nighttime phenomenon we call the aurora borealis, or northern lights. There is no easy way to accurately predict when it will happen or what you'll see — a subtle glow in the north that lasts all night long, or a brief but spectacular flurry of red and green lights and rays. An occasional display of northern lights is just one of those rewards you get for being a dedicated skywatcher. You won't see anything if you're inside watching TV.

## The Moon

Another important cycle of time is the monthly change of the Moon's phases. Our ancestors probably knew this cycle better than we do. Follow the Moon through one of its cycles. Starting around the time of New Moon, make daily observations of the Moon. Note its phase and location in the sky. If you're a veteran observer looking for more of a challenge, see how soon after New Moon you can pick out a "young" Moon — that tiny sliver of a crescent that appears an evening or two after New Moon.

The distractions of modern living may have lessened our intimacy of the night sky, but at least we don't panic at the sight of a lunar eclipse. We won't be trying to drive away demons when the Moon drifts into Earth's shadow on the evening of March 23–24 and is nearly totally eclipsed. The Moon never looks quite the same from one eclipse to the next. Will it be a bright copper red ball or a barely visible grayish disk? Find out on eclipse night. For more details, see page 52.

As the Moon orbits Earth, it occasionally passes in front of (occults) a

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Andrew Cottam

**Solitary Venus in the Evening**

planet or bright star. During 1997, we'll be treated to a series of occultations involving Saturn and Aldebaran. Saturn will slowly disappear, but Aldebaran will blink out of view. The Moon also skims past both Saturn and Aldebaran during the year.

## Planets

Five of the planets may be glimpsed with the unaided eye (a sixth, if you count Earth — even a seventh, since Uranus may be faintly glimpsed by keen-eyed observers). Brightest of the five is Venus, which shines low in the east each morning until an early April conjunction with the Sun. Venus won't become a prominent evening planet until late in the year, greatest elongation from the Sun occurring on November 6. When Venus pairs up with a crescent Moon, as it will on the evenings of September 5, October 5, November 4, and December 3, the sight is one of rare beauty. Venus is so bright that, if you happen to glimpse the Moon before sunset on one of these dates, you might actually see Venus as well. The sight of a white "star" shining in the blue of the daytime sky is both startling and fascinating.

Venus is easy to view. The other inner planet, Mercury, isn't. Mercury spends most of the time hiding in the Sun's glare. Only during favorable elongations is the tiny planet visible for a week or two. Windows of opportunity for 1997 occur around April 5 (evening) and September 16 (morning). Even then, you'll need a viewing site open to the east (morning) or west (evening). To glimpse for the first time that elusive planet (that legend says even the great Copernicus never saw) is a lifetime thrill.

Arguably the most interesting planet to the unaided eye is Mars. Its distinct red color and great range in brightness (from magnitude –2.0 during a favorable opposition to a comparatively feeble 1.0 near conjunction) set Mars apart from the other planets. This year, Mars reaches opposition

### The Year's Best Meteor Showers

| Date | Shower | Hourly Rate | Conditions |
|---|---|---|---|
| Jan. 3 | Quadrantids | 85 | Moon interferes |
| Apr. 22 | Lyrids | 15 | Full Moon |
| May 5 | Eta Aquarid | 30 | New Moon |
| Aug. 12 | Perseids | 100 | First Qtr. Moon |
| Oct. 21 | Orionids | 20 | Moon interferes |
| Nov. 17 | Leonids | 12 | Moon interferes |
| Dec. 14 | Geminids | 95 | Full Moon |
| Dec. 22 | Ursids | 20 | Last Qtr. Moon |

(magnitude –1.3) in mid-March in the constellation Virgo. As Earth overtakes and passes Mars around this time, the Red Planet appears to move backward (retrograde) against the background stars of Virgo. Eventually, Mars resumes its normal west-to-east track. Chart this retrograde loop by making weekly observations of Mars from January through June.

Second only to Venus in brilliance is Jupiter. In conjunction with the Sun in January, Jupiter is a morning planet throughout the spring and early summer. An opposition in Capricornus during August brings the big planet into the evening sky, where it remains for the rest of the year. An eye-catching congregation of planets, slated for the closing evenings of 1997, includes Jupiter, Mars, and Venus.

Though not as brilliant as Venus or Jupiter, Saturn has an almost stately appearance when viewed with the unaided eye. Saturn begins the year as

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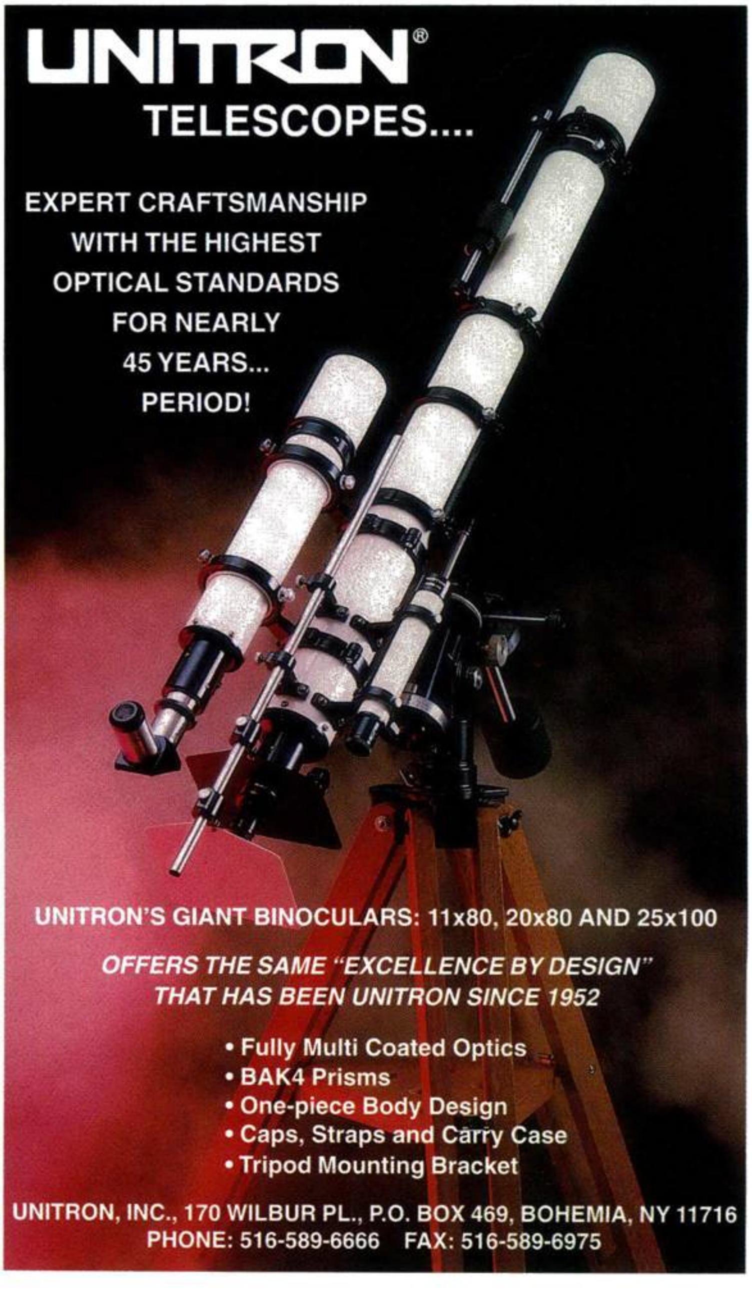

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an evening planet in Pisces, its home constellation throughout 1997. Lost in the Sun's glare for several weeks around a late-March conjunction, Saturn reemerges as a morning planet. Best viewing is from the time of Saturn's October 10 opposition until the end of the year.

### Comets

Unless you've been camping out on a glacier for the past year, you know that 1997 is the year of Comet Hale-Bopp. Bright naked eye comets like this (and Hyakutake, which delighted skygazers last year) are true cosmic spectacles. Comets tend to be unpredictable (ask those who remember the Comet Kohoutek hype and ultimate fizzle back in the early 1970s). But if Hale-Bopp lives up to expectations, we should see a performance even better than that of Hyakutake. You'll want to probe this mysterious visitor with whatever optical aid is at hand, but you won't be able to capture all of it in the limited field of binoculars and telescopes. Better to just stand and watch this magnificent object as it hovers in the sky above. See page 62 for more details.

### Meteor Showers

Perhaps the best case for naked eye observing is the bright meteor that streaks across the sky. One amateur astronomer, with many hundreds of hours of night sky observing, recalls seeing his brightest meteor while attending a night football game. The fireball blazed across the sky, silently breaking up in a shower of glowing fragments. Spectators on the side of the stadium facing the spectacle cheered wildly, leaving fans across the stadium and football players huddling on the field confused.

More predictable are the meteor showers. These cosmic fireworks displays arise when Earth, in its annual track around the Sun, passes through the trail of debris left by a comet. For several nights, a shower of these sand-to-gravel-sized chunks of rock will descend into Earth's atmosphere. Each remnant, traveling at speeds between 30 and 65 kilometers per second, burns up, leaving a fiery streak of light — the so-called shooting star.

Of the numerous annual meteor showers, only a handful are rich enough to warrant time from the casual observer. Even then, you won't actually see a shower. More realistic is a trickle of meteors — one per minute, perhaps a handful each minute, if things are cooking. See page 54 for a list of the best, with observing prospects for 1997. Bear in mind that the numbers listed for hourly rate refer to peak activity, which can vary greatly from year to year.

The best way to observe a meteor shower is to dress comfortably for the occasion and go out to a site with an open view of the area of sky where the meteors will be visible. Although meteors may be visible after sunset, peak activity often occurs after midnight. Whether you want to get serious, recording hourly meteor counts, or simply sit back and enjoy the show, is up to you.

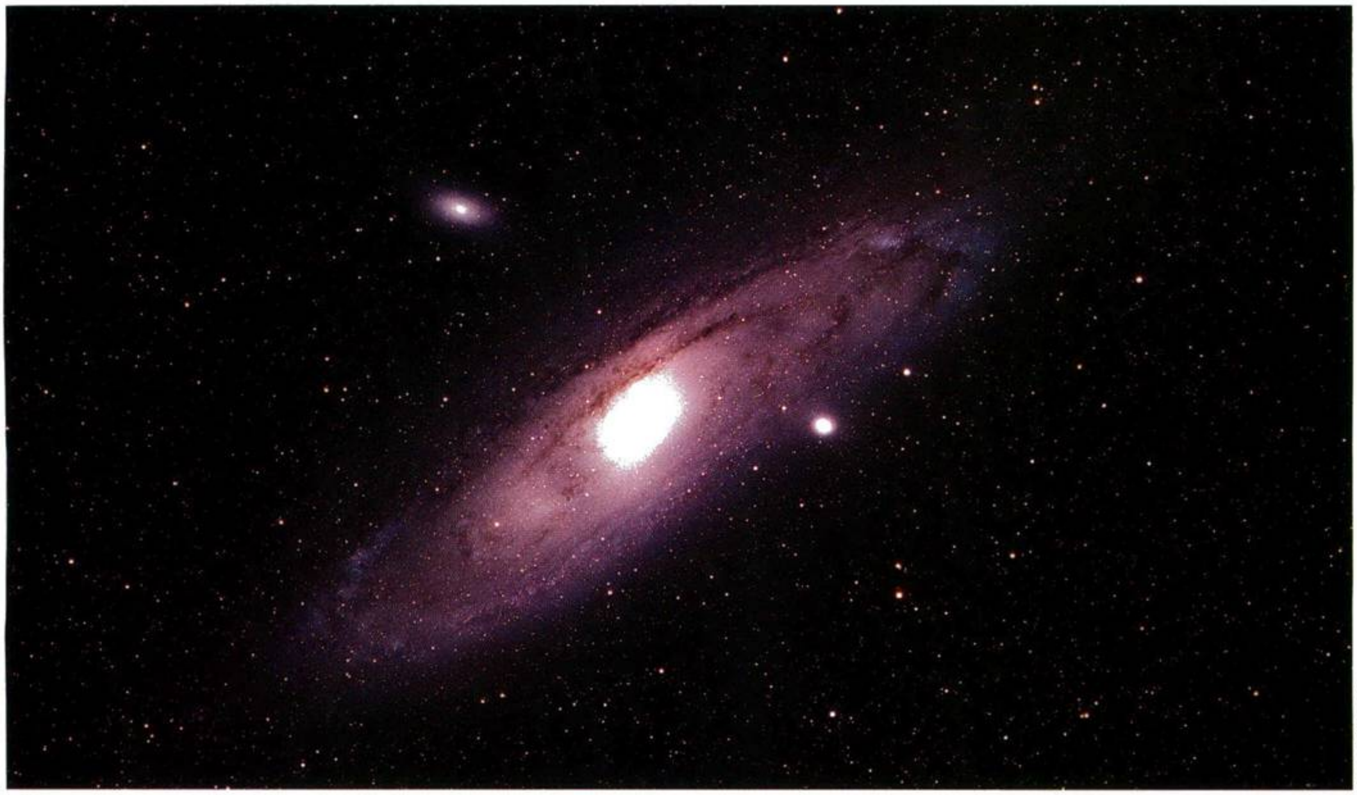
### Stars and Constellations

Most of what we see in the night sky are stars — thousands of them. If you're just starting out, you'll need to become familiar with the major stars and constellations before you can explore the deep-sky realm. Veteran skygazers would do well to pull out a star atlas and track down some of the minor constellations, like Lynx, Lacerta, and Equuleus. Once you've become familiar with the bright stars and constellations and have watched them over a few years, they become signposts of the seasons. The appearance of Arcturus in the eastern sky after sunset is as sure a sign of spring as the first robins. Orion in the east after sunset heralds the coming of winter.

Even the most casual skygazer notices that stars shine at different

**A Meteor Zips Through Orion**

Timothy Huettner



George Greaney

The Andromeda Galaxy

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brightnesses. Less obvious is that the brightest stars — the so-called 1st magnitude stars — are not all white. Some, like Capella and Arcturus, are distinctly yellow, while others are orangy-red.

More surprising to the beginner is the fact that many stars vary in brightness. The star Mira (Omicron [o] Ceti) in the constellation Cetus shines for several weeks at 2nd or 3rd magnitude. Then it slowly fades from view, becoming invisible to the unaided eye for several months. Eleven months later, Mira again shines as a bright naked eye object. Mira is the prototype of a class of pulsating red supergiants called the "Mira-type," or long-period variables. Another pulsating variable easily seen with the unaided eye is Delta (δ) Cephei, the prototype Cepheid variable. Cepheids differ from Mira-type stars in that their periods are several days to a few weeks, and the magnitude range is much less. Two other celebrated naked eye variables aren't really variable at all. Beta (β) Lyrae and Algol (Beta Persei) both undergo variations

**Orion and Canis Major**

Luke Dodd

in brightness because each is an edge-on binary system. As one star passes in front of the other, you'll see a dip in the brightness of the system as a whole.

### Going into Deep Space

People who live in rural areas know how just one light can diminish the splendor of the night sky. City dwellers have to contend with a massive invasion of artificial light. A neighbor's intrusive spotlight, a billboard near a large suburban mall, or the lights of a thousand office buildings are all forms of light pollution. Conquering light pollution may be as simple as asking a neighbor to shield his outdoor light, or as involved as lobbying city officials to establish sensible lighting bylaws. Need help or advice? See the information about clubs and organizations on page 46.

When you do find a dark sky, gaze up at a tiny and delicate gathering of a half dozen stars visible in the winter evening sky. Shining like dewdrops in the morning Sun, the stars immediately catch our attention. These form the Pleiades (M45), or Seven Sisters. Their dipper-shaped arrangement has tricked many beginners into thinking they've found the Little Dipper. The Pleiades are the classic example of an open star cluster — a region where a cloud of gas and dust, a nebula, has given birth to a clutch of stars. The Pleiades is also a prime example of a deep-space object whose naked eye appearance is better than what you'll see in most telescopes.

There are other naked eye clusters, and a handful of nebulae that can be discerned without optical aid. Their distances boggle the mind — several thousand light-years, in some cases. How far can the unaided eye pierce the depths of space? You'll find the answer in a fuzzy patch of light in the constellation Andromeda. This is the Andromeda Galaxy (M31), an enormous aggregation of stars located 2.2 million light-years from Earth. Gaze at this galaxy, and the light entering your eyes left on its journey through space long before the last Ice Age.

As you squint to see the Andromeda Galaxy or any of these other fuzzy patches in the night sky, you'll wish for a way to see farther and clearer. It's time to consider some form of optical aid. ☐

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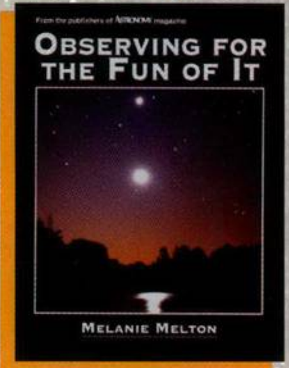
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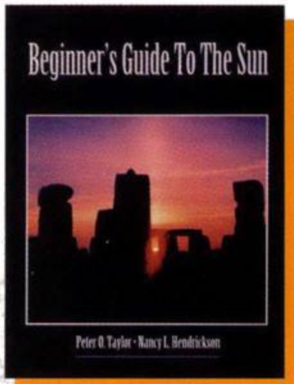
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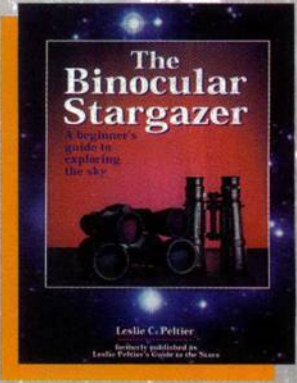
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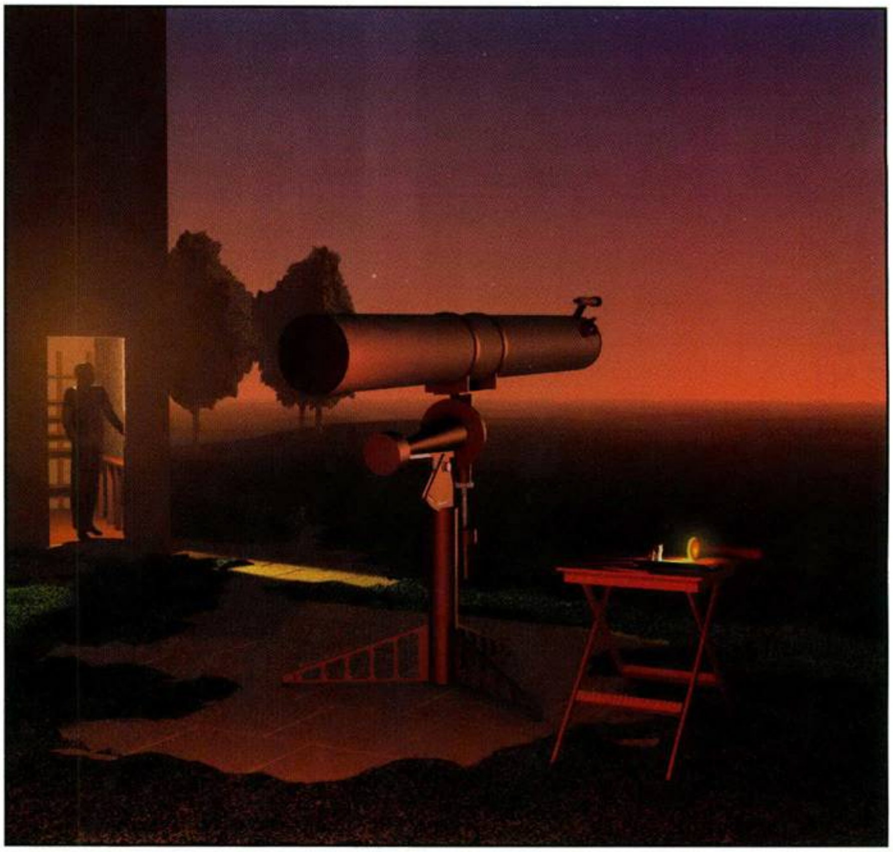
Julian Baum

The night sky, so vast and mysterious, begs to be viewed with some kind of optical aid. And no matter what "eye enhancer" you use, you'll always want something bigger. Binocular owners will yearn for a telescope, telescope owners will suffer from "aperture fever" — that insatiable desire for an even larger telescope. No matter how far you can peer into space, you'll want to probe deeper.

What do you need to explore the heavens? That depends on your interests and level of experience. No single optical device can do it all, which is why the well-equipped amateur astronomer owns several telescopes. The following equipment packages should cover most observing situations.

This is the basic package that all skygazers should have. If you're a beginner, it paves your way to the stars. If a veteran, the items listed in this package serve as the foundation for your observing.

### Package 1, The Bare Essentials

(Recommended for observers of all levels)

You will need:
- Your eyes
- Planisphere
- Star atlas and guidebook
- Subscription to ASTRONOMY
- Clipboard, red flashlight, paper, and pencils

The single most important piece of observing equipment you will ever need are your eyes. Everything else merely enhances what they do. It's easy to take them for granted, but your eyes deserve the same tender loving care routinely given to an expensive eyepiece.

A planisphere is a wheel-shaped gadget that shows which stars and constellations are visible at a certain time and date. It's useful to the beginner learning the stars and constellations and the veteran planning an evening observing session.

A star atlas and guidebook picks up where the planisphere leaves off. More detailed than the planisphere, these accurately plot all stars down to a specified limiting magnitude (for beginners, this should be mag. 5 or 6) and shows the location of major nonstellar objects. Besides the star charts, a good star atlas contains tables of data on selected sky objects and a how-to section on general skygazing. Good beginning atlases and guides include *Beginner's Guide to Amateur Astronomy* by David J. Eicher (Kalmbach, 1993), *Beyond the Solar System* by David J. Eicher (AstroMedia, 1992), *Cambridge Star Atlas 2000.0* by Wil Tirion (Cambridge Univ. Press, 1991), *Color Star Atlas* by John Cox and Richard Monkhouse (Kalmbach, 1991), *The Observer's Sky Atlas* by Erich Karkoschka (Springer-Verlag, 1988), and *Skywatching* by David H. Levy (The Nature Co., 1994).

The planisphere and star atlas are good only for the fixed sky objects (stars and deep-space objects). If you want to know the status of the Sun and Moon, planets, asteroids, and comets, you'll need up-to-date information. That's where ASTRONOMY comes in. The Sky Almanac found in each issue of ASTRONOMY contains current information on the denizens of our solar system.

A good observer keeps records of the sky events or sights he or she sees. A clipboard with unlined paper (preferably with three holes for later insertion in a binder) and some #2 pencils for sketches and notetaking will do the job. You'll also need a flashlight covered with red cellophane or a red plastic filter to reduce glare and preserve your night vision.

Interested in testing the astronomical waters but not sure if a telescope is for you? Try binoculars. Binoculars are a surprisingly versatile astronomical tool, able to bring to light a large number of sky objects. In fact, binoculars actually outperform telescopes on selected sky objects (notably bright comets and large star clusters). A pair of binoculars is a wise choice for the beginner, because it's less expensive

### Package 2, The Binocular Observer

(Recommended as a bridge between naked-eye and telescope observing)

You will need:
- Bare Essentials Package
- Binoculars (7x50 or larger)
- Binocular guides

and easier to use and maintain than a standard telescope. And should you discover that astronomy isn't a hobby you'd like to pursue, your binoculars will prove valuable for a variety of non-astronomical activities (watching sporting events, for example). If you decide to buy a telescope, your binoculars will continue to serve as a useful observing tool. Veterans use binoculars to fill that niche between naked eye observing and high-power telescope viewing.

Binoculars come in a large array of sizes, but your best bet is the 7x50 size. The 7 stands for the magnifying power, and the 50 is the diameter, in millimeters, of the front lenses. The common 7x35 size binocular will work, but collects only half as much light as the 7x50s. And in astronomy, how much light your optical aid collects is very important. Larger binoculars show more but are more difficult to hold by hand.

Excellent guides for binocular observing may be found in *Binocular Astronomy* by Craig Crossen and Wil Tirion (Willmann-Bell, 1992), *The Binocular Stargazer* by Leslie C. Peltier (Kalmbach, 1995), and *Touring the Universe through Binoculars* by Philip S. Harrington (Wiley, 1990).

Though the telescope isn't an absolutely essential astronomical tool, no serious skygazer would be without one. And you don't need an observatory-sized telescope to cruise around the Galaxy. An amazing array of space sights, from our cratered Moon to galaxies millions of light-years away, can be bagged with small scopes. For the beginner, a small telescope offers a user-friendly way to explore the night sky. The veteran will appreciate the portability of a small telescope on those occasions when it's just not practical to lug out that 20-inch Dob.

We've already mentioned that no

### Package 3, The Small Telescope Observer

(Recommended for first-time telescope owners and experienced skygazers who need something portable)

You will need:

- Bare Essentials Package
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### Package 4, The General Observer

(Recommended for the casual observer who seeks higher performance than what a small scope offers)

You will need:
- Bare Essentials Package
- 6-inch f/8 Newtonian reflector
- A moderately detailed atlas and guides

single telescope works well on all kinds of sky objects. But the classic 6-inch f/8 Newtonian reflector comes close. It's big enough for serious sky-gazing, yet remains reasonably portable. The f/8 focal ratio ensures a wide field for big targets, while permitting a quality high-power grasp of planets and double stars. Budget-conscious individuals will like the relatively low cost. The 6-inch f/8 Newtonian reflector can do it all.

Suitable atlases and guides include *The Backyard Astronomer's Guide* by Terence Dicksinson and Alan Dyer (Camden House, 1991), *Burnham's Celestial Handbook* by Robert Burnham, Jr. (Dover, 1978), *The Guide to Amateur Astronomy*, 2nd ed., by Jack Newton and Philip Teece (Cambridge Univ. Press, 1994), *Sky Atlas 2000.0* by Wil Tirion (Cambridge Univ. Press, 1981), *Star-Hopping* by Robert Garfinkle (Cambridge Univ. Press, 1994), and *The Universe from Your Backyard* by David J. Eicher (Cambridge Univ. Press, 1988).

Having sampled everything the night sky has to offer, you may find that certain sky objects have captured your interest more than others. Perhaps you're intrigued by high-power targets like the moon and planets, double stars, or planetary nebulae. If so, you need a telescope that delivers optimum images at the highest practical magnifications. A large, long-focus refractor is the telescope of choice. You'll spend a lot of money for such an instrument, and you'll probably want to consider housing it in some sort of permanent outdoor shelter. But a big refractor will reward you with a lifetime of high-powered fun.

### Package 5, The Lunar and Planetary Observer

(Recommended for high-power, high-resolution observing)

You will need:
- Bare Essentials Package
- Advanced atlas
- Planetary and lunar guides
- 4- to 6-inch, f/10 to f/15 apochromatic refractor

Owning a large telescope means you'll need an advanced star atlas, like *Sky Atlas 2000.0* by Wil Tirion (Cambridge Univ. Press, 1981) or *Uranometria 2000.0* by Wil Tirion, Barry Rappaport, and George Lovi (Willmann-Bell, 1987–1988). You'll also want a guidebook that refers to your area of interest, such as *ASTRONOMY Atlas of the Moon* by Antonín Rükl (Kalmbach, 1993), *Introduction to Observing and Photographing the Solar System* by Thomas A. Dobbins, Donald C. Parker, and Charles F. Capen (Willmann-Bell, 1988), and *The Moon: An Observing Guide for Small Telescopes* by Michael T. Kitt (Kalmbach, 1991).

Specialized work means specialized accessories. If you're doing lunar and planetary work, consider purchasing a good set of filters. Filters reduce glare and increase contrast to enhance the visiblilty of subtle lunar and planetary detail. Serious double star observers will want a micrometer for making accurate measures of their separations.

Want to see intricate detail in large objects like the Andromeda Galaxy or the Orion Nebula? Need wide-field views of star fields for variable star work? Your workhorse will be the large-aperture, short-focus Dobsonian reflector. Its size is limited only by your pocketbook and the nature of observing area. If funds are limited or you lack a permanent observing site and need portability, choose a 10- or 13-inch Dobsonian-mounted reflector. Otherwise, go for a 16-inch or larger Dob.

### Package 6, The Deep-Sky Observer

(Recommended for exploring the universe beyond the solar system)

You will need:
- Bare Essentials Package
- Advanced atlas
- Deep-sky guide
- 12-inch or larger Dobsonian-mounted reflector

As atlases and guides go, try *Galaxies and the Universe*, edited by David J. Eicher (Kalmbach, 1992), *Stars and Galaxies*, edited by David J. Eicher (AstroMedia, 1992), *Turn Left at Orion* by Guy Consolmagno and Dan M. Davis (Cambridge Univ. Press, 1989), and *Uranometria 2000.0* by Wil Tirion, Barry Rappaport, and George Lovi (Willmann-Bell, 1987–1988).

If you're a cutting edge individual, you'll probably be attracted to the high-tech side of amateur astronomy. Few aspects of amateur astronomy are more cutting-edge than astrophotography. Thanks to the high quality films available today, amateur astronomers are taking breathtaking deep-space photos that rival those taken by professional astron-omers in observatories.

### Package 7, The Astro-Imager

(Recommended for anyone interested in cutting-edge imaging of stars, planets, and galaxies)

You will need:
- Bare Essentials Package
- 8-inch or larger SCT
- Camera or CCD camera
- Film or computer with software
- Astro-imaging guides

The CCD camera takes this quality to a new level. Understand that being a successful astro-photographer is an expensive proposition, and it doesn't happen overnight. Well-known astrophotographers have paid their dues, having spent many hours taking dozens to hundreds of exposures before getting it right.

To immerse yourself into this world, consult *Astrophotography for the Amateur*, rev. ed., by Michael Covington (Cambridge Univ. Press, 1991), *Choosing and Using a CCD Camera* by Richard Berry (Willmann-Bell, 1992), *High Resolution Astrophotography* by Jean Dragesco (Cambridge Univ. Press, 1995), *Introduction to Astronomical Image Processing* by Richard Berry (Willmann-Bell, 1991), and *A Manual of Advanced Celestial Photography* by Brad D. Wallis and Robert W. Provin (Cambridge Univ. Press, 1988).

## Optical Systems

**The eye.** The eye, with its flexible convex lens and sensitive light-receiving retina, is a simple, but incredibly effective optical system. Able to focus and adjust to various light levels instantly and able to discern a million different colors, the eye is your primary observing tool.

**Binoculars**. The standard binocular is nothing more than a pair of identical refracting telescopes mounted together. Prisms inside the binoculars correct the upside-down image telescopes produce. A view through binoculars is typically more pleasing than what you get from a telescope, because both eyes are used.

**Refracting Telescope**. The refracting telescope uses a convex lens to collect light and form an image, and an eyepiece to magnify that image. With their incredibly sharp images, refractors are the choice of astronomers who prefer viewing lunar or planetary detail or close double stars. Refractors are generally easier to care for, but are expensive. Cheaper versions may suffer from color distortions.

**Reflecting Telescope**. A reflecting telescope collects light with a concave mirror. Light is then deflected off a small secondary mirror to the eyepiece. The wide fields of reflectors make them a favorite of deep-sky observers. Reflecting telescopes require more care than refractors. The mirrors often need realigning and, after a number of years, recoating. Still, reflectors are much less expensive than similar-sized refractors and catadioptrics.

**Catadioptric Telescope**. The catadioptric is a hybrid. The most popular type, the Schmidt-Cassegrain (SCT), uses mirrors and lenses. Light passing through a correcting plate strikes a concave mirror, is then sent to a secondary mirror mounted on the correcting plate, then back through a small hole in the main mirror to the eyepiece. This "folded" system allows a long focal length in a short tube. Catadioptrics offer the best features of both refractors and reflectors, but tend to be pricey.

### Telescope Mountings

**Altazimuth**. This is the mount found on most inexpensive telescopes. Aiming is done by side-to-side (azimuth) or up-and-down (altitude) motions. The altazimuth mount is easy to operate, but inexpensive designs tend to be rickety.

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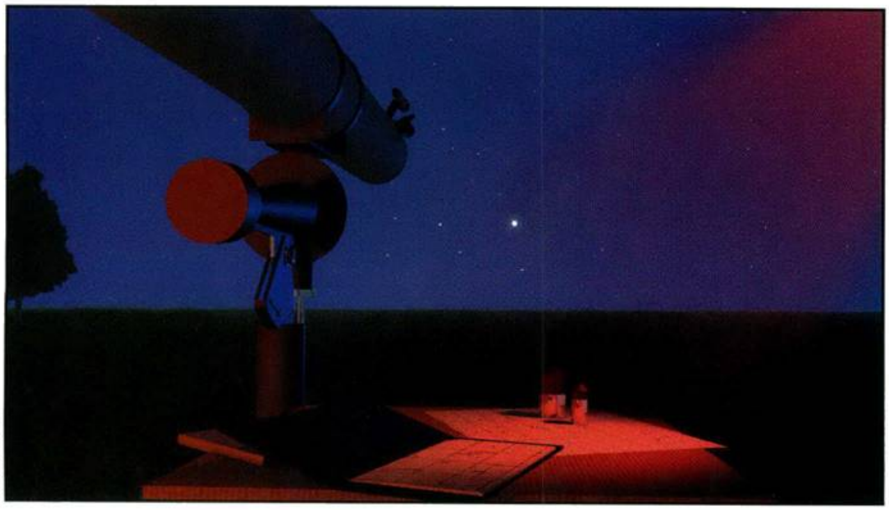

Julian Baum

**Dobsonian**. This modification of the altazimuth mount, developed by California amateur John Dobson, is a marvel of simplicity. Flanges on the telescope tube fit into grooves in a large box-shaped structure. With the tube assembly in place, the telescope can be raised and lowered in altitude. A bolt in the bottom center of the box is attached to the middle of a base plate, allowing the box to swivel in azimuth. The beauty of the Dobsonian mount is that the more weight you add, the more stable the mount becomes.

**Equatorial**. An altazimuth mount can't follow the sweeping arcs or circles that Earth's rotation imparts on sky objects. Enter the equatorial mount. With one axis aligned on the celestial north pole, the remaining axis nicely follows an object's path across the sky. The equatorial mount, with drive motor added, is ideal for long-term viewing and astrophotography or CCD work.

## Eyepiece Designs

The eyepiece is the part of a telescope that does the magnifying. Not a fixed part of the telescope, it slides in and out of a drawtube or focusing mount. This lets you change eyepieces (and magnifying powers) easily. Eyepieces come in three standard barrel diameters, 0.965, 1.25, and 2.0 inches. The 0.965-inch eyepiece is a mainstay of the standard 60mm refractor. The 1.25-inch eyepiece is the most common size, and is used with most mid-sized telescopes. You can upgrade a 60mm refractor to accept 1.25-inch eyepieces by inserting a 0.965 to 1.25 adapter into the focuser. The 2-inch eyepiece is a favorite of large-scope owners.

About as confusing as the variety of telescopes available is the array of eyepiece types. The best advice is to keep it simple. Two or three eyepieces and a good-quality Barlow lens to boost their magnifications are all you need.

First, you'll want a low power eyepiece, one that magnifies about 5x–10x per inch of aperture. Any time you're aiming your telescope at a sky object, low power enables you to find it faster. Low power also produces spectacular wide-field views of comets, star fields, and large deep-space objects. A medium power eyepiece (20x–30x per inch) is recommended for close-up views of the moon and planets under typical sky conditions. A Barlow lens to boost the magnifications of your low and medium power eyepieces effectively increases your repertoire of available magnifications. Most evenings, sky conditions won't allow use of a high-power eyepiece (40x–50x per inch). Purchase one only after you've already acquired your low and medium power eyepieces.

What eyepiece design should you purchase? Here's the rundown on the major types.

**Huygenian** and **Ramsden**. These eyepieces have a bad reputation, because they usually come with cheaply made department store telescopes. No doubt about it, these designs are inferior to other eyepiece types. Huygenian and Ramsden eyepieces have one useful function, viewing the Sun by solar projection. Because both designs consist of two separate lenses, there are no cemented optics to "cook" in the Sun's intense heat. Be careful that the lenses are glass and not plastic before contemplating this, however.

**Kellner**. The Kellner improves the Ramsden design by replacing one lens with an achromatic doublet. This popular eyepiece is relatively inexpensive, and works well with low powers.

**Orthoscopic**. More expensive than the Kellner, the Orthoscopic is a great high-power eyepiece. The eyepiece sets of many amateurs include Kellners for low to medium powers, and an Orthoscopic eyepiece for high magnifications.

**Plössl**. This popular, moderately expensive design produces fine fields over a wide range of focal lengths. It is especially effective with short-focus telescopes.

**Erfle**. Want a spectacular wide field of view at a reasonable cost? The Erfle eyepiece is the answer. A drawback is the edge-of-field distortion, especially when used with short-focus telescopes.

**Wide Field**. The advent of modern computer-generated eyepiece design has led to some truly remarkable wide-field eyepieces that virtually eliminate the field distortions of the Erfle. Wide-fields produce truly breathtaking views — like looking out the porthole of a spaceship. The typical wide-field eyepiece will cost as much as a handful of Kellners. But, as anyone who has ever viewed the Orion Nebula with a wide-field will tell you, it's worth it.

**Barlow lens**. The Barlow isn't an eyepiece. It's a booster lens that effectively increases the magnification of the eyepiece coupled with it. Barlows have a bad reputation, because of the widespread use of cheap Barlows with department store telescopes to produce those ridiculously high magnifications they advertise. Plug your highest power eyepiece into any Barlow lens, and you'll get a terrible image. But use a good-quality Barlow with your low-power eyepieces and you have a useful tool that effectively expands your eyepiece arsenal.

## Telescope Glossary

**Aperture**. This is the diameter of a telescope's objective lens or mirror. The aperture determines a telescope's light-gathering power (how faint an object you can view) and the upper limit of magnification you can use (a telescope's maximum useful power is normally about 50x per inch of aperture).

**Field of View**. The apparent width of sky, in degrees, you can see with an eyepiece.

**Focal Length**. The focal length of a telescope is the distance from the objective lens or mirror to the image it forms. The longer the scope's focal length, the higher the magnification it will yield with a particular eyepiece.

**Focal Ratio**. A telescope's focal length, divided by the aperture. "Short focus" telescopes of focal ratio f/6 or less produce wide, rich-field views, ideal for observing large deep-sky objects. Long-focus systems (f/10 or longer) allow higher magnifications useful for lunar and planetary work. The middle-ground f/8 ratio is ideal for general observing.

**Magnifying Power**. How many times larger an object is when viewed with a telescope. It is calculated by dividing a telescope's focal length by the focal length of the eyepiece being used. The focal length of an eyepiece determines the magnification it will generate. The lower the eyepiece focal length, the higher the magnification.

### Buying Tips

What's the wisest way to obtain astronomical equipment? Begin with an idea of what you need. That's why we looked at the various observing packages earlier in this section.

Once you have something definite in mind, you have several options: direct purchase of new equipment through a store or mail order catalog, or the aquisition of used goods at a yard sale or through the classified ads in ASTRONOMY.

If your budget is tight, don't worry. Optical goods retain their original condition if well cared for. A used telescope or eyepiece can work as well as one purchased brand-new, for a fraction of the cost. Do you want your telescope right away? If so, you'll prefer store-hopping or searching the yard sales. Direct purchase also lets you inspect before buying. If time is no problem or the stores and yard sales turn up dry, take the mail order route. Whatever avenue, be sure your purchase is guaranteed. By doing so, you'll ensure many nights of enjoyment under the stars. ☐

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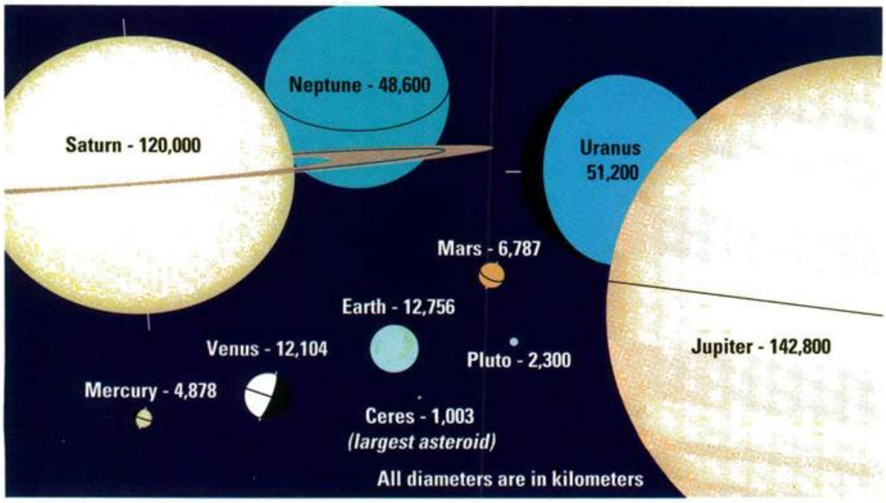
**The Moon, Venus, and Jupiter**

# Journey Through the Solar System

The solar system consists of one average-sized star (the Sun) and the multitude of small bodies that orbit it. Compared to the rest of our Galaxy and the universe as a whole, it's but a tiny speck. Yet that speck is a universe in miniature, filled with wonders to explore. From the Sun to Pluto, and all the planets, moons, asteroids, comets, and meteoroids in between, there's enough to provide you with the cosmic cruise of a lifetime.

The best place to start is right here on Earth. If you're a beginner, terrestrial observations made during daylight hours will get you aquainted with your telescope. You can practice aiming and focusing without the frustration of fumbling around in the dark. Do veteran skygazers benefit from terrestrial observing? You bet. What better way to try out a new telescope or experiment with an eyepiece, especially when skies are cloudy or moonlit.



All diameters are in kilometers

ASTRONOMY: Lee Vande Visse

## One Giant Leap

Once everything is in order, it's time to make that "giant leap for mankind," to the Moon, of course. The Moon is an ideal beginner's target. Big and bright, it shows a wealth of detail in the smallest of telescopes. The sight of this cratered world never fails to inspire beginner and veteran alike. Slip a high-power eyepiece into the telescope and just watch the Moon glide across the field. Suddenly you become an astronaut, peering at this world from the porthole of your spaceship.

It's fun to go outside and use a telescope and Moon map to navigate your way around the lunar surface. The Moon is somewhere in the sky just about any time during the month.

Prime time for evening observing begins two or three nights after New Moon and continues until two or three nights before Full Moon. During this 10-evening span, you'll be able to visit the Moon's most celebrated features as the terminator (the boundary between day and night on the Moon) sweeps across its surface. What are the Moon's best tourist attractions? Here's a list of some favorites. Parentheses provide the number of evenings after New Moon that each feature is best visible.

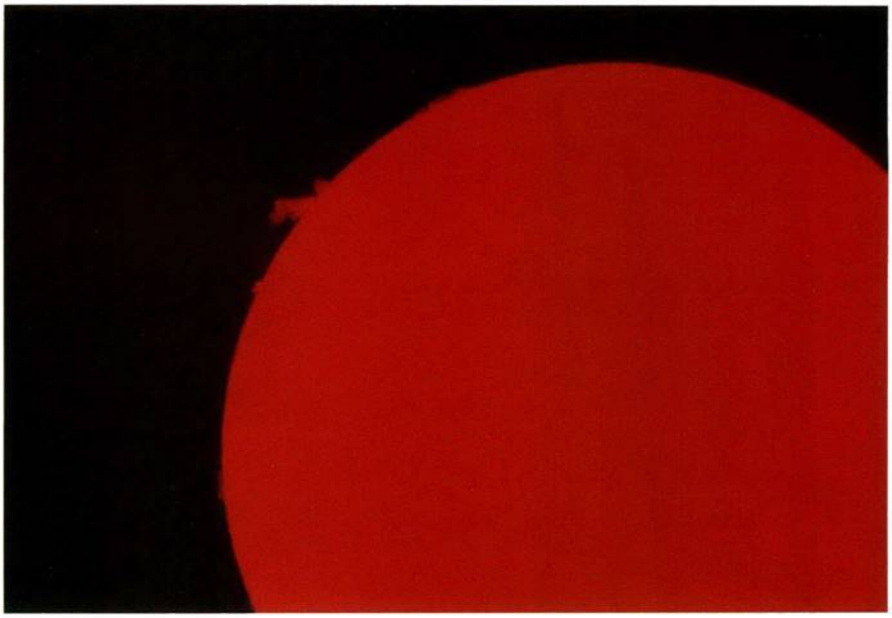
**Maria**. Mare Crisium (3), an oval-shaped sea that bisects the crescent Moon; Sinus Iridium (10), a striking "bay" in Mare Imbrium.

**Craters**. Cleomedes (3), 126-km diameter, located just north of Mare Crisium; Langrenus (3), 132 km, on eastern edge of Mare Fecunditatis; Petavius (3), 177 km, 5 km deep; Posidonius (5), 95 km, ancient crater with a flat floor; Aristoteles and Eudoxus (6), 87 km and 67 km, an eye-catching pair of high-walled craters; Theophilus, Cyrillus, and Catharina (6), 100 km, 98 km, and 100 km, form a magnificent three-crater chain; Hipparchus and Albategnius (7), 150 km and 136 km, a pair of huge craters; Ptolemaeus, Alphonsus, and Alpetragius (8), 153 km, 110 km, and 40 km, another outstanding three-crater chain; Archimedes (9), 83 km, a beautiful flooded crater on the southern edge of Mare Imbrium; Clavius (9), 225 km, one of the Moon's largest walled plains, near the Moon's south pole; Copernicus (9), 93 km, perhaps the finest lunar crater; Plato (9), 101 km, a dark walled plain located in the lunar Alps; Tycho (9 and Full Moon), 85 km, a relatively young crater, sports a bright ray system, best seen around Full Moon.

**Mountains**. Alpine Valley (7), a "gash" in the lunar Alps; Caucasus Mountains (7), a lofty lunar range, located on the northwest edge of Mare Serenitatis; Piton (7), a striking isolated peak that juts straight up from the Mare Imbrium, 2250 m high; Apennines (8), an outstanding curved lunar range, forming the southeastern border of Mare Imbrium; Pico (8), a striking solitary peak rising from the Mare Imbrium, 2400 m high.

**Other features**. Ariadaeus and Hyginus rilles (7), a broad system of cracks located near the center of the Moon's disk, each about 240 km long; Straight Wall (8), a 110-km long fault line, appearing as a dark line west of the crater Arzachel.

Don't forget the lunar eclipse on the evening of March 23–24. While naked eye viewing or binoculars will provide satisfactory viewing, you'll want to zoom in on the Moon with your telescope. Just be aware that the Moon is terrifically bright during the early and late stages of an eclipse. Use a Moon filter or limit your gazes to a few seconds at a time. As the eclipse unfolds, your telescope will permit a view of Earth's shadow creeping slowly across the lunar surface. For more on the eclipse, see page 52.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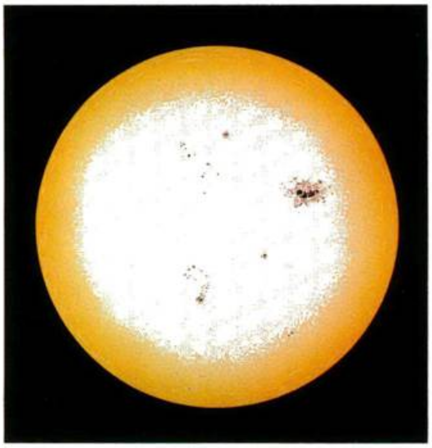
**A Solar Prominence in Hydrogen-Alpha**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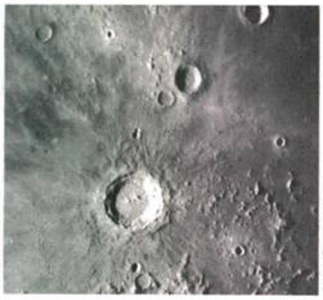
**The Sun Sketched with a Small Telescope**

Dan Schechter

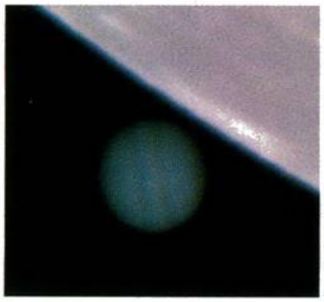
**The Moon with Earthshine**


Jean Dragesco

**Lunar Crater Copernicus**

Lauri Mala

**The Moon in Eclipse**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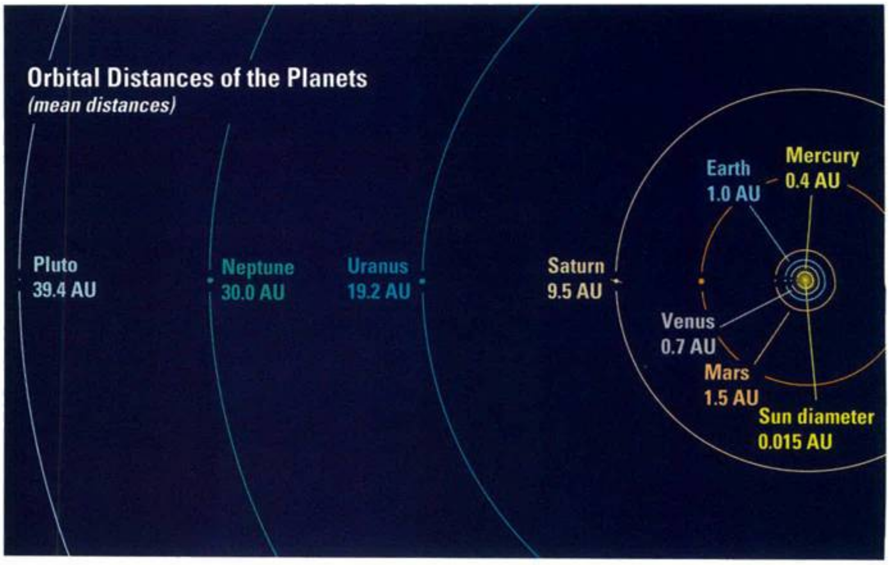
**The Moon Occults Jupiter**



ASTRONOMY: Lee Vande Visse

Lunar occultations of planets and bright stars are fascinating telescopic events, with the Moon passing in front of background points and disks of light. The best for 1997 involve the bright star Aldebaran and the ringed planet Saturn. When the Moon occults a sky object, you can actually perceive motion immediately prior to contact. It looks as though the Moon is stationary, and the star or planet is plunging into its surface. If a star is occulted, it suddenly blinks out of sight. Reappearance is just as abrupt and harder to capture, because you never know exactly where and when the star will reappear. A planetary occultation appears to take place more gradually. The dates of the Aldebaran and Saturn occultations visible from North America are listed below. For precise times and locations, refer to the current ASTRONOMY.

Aldebaran. Jan. 19, Feb. 15, Apr. 11, July 29, Aug. 25, Oct. 19, Dec. 13.

Saturn. May 4, June 28, July 25, Sept. 18, Nov. 12, Dec. 9.

One final note on the Moon. Its half-degree disk is a handy measuring tool for determining the true field of view of an eyepiece. If three Moons fit across an eyepiece field, the field of view is 1½°. If your eyepiece captures just one-half of the Moon, you're working with a ¼° field of view. And so on. Knowing the true field of view of an eyepiece tells you how large a chunk of sky it can capture.

### The Nearest Star

Astronomy doesn't have to be a nighttime hobby. On any cloudless day, the nearest star, the Sun, is at your disposal. Just remember never to look at the Sun directly through a telescope. Or the finderscope, for that matter. And don't even think about using one of those screw-in Sun filters that come with many inexpensive telescopes. The Sun's heat, collected and concentrated near the eyepiece, can literally crack such a filter.

The beat way to view Old Sol is by the projection method, and the ideal telescope for this purpose is the standard 60mm refracting telescope. A 60mm refractor collects just the right amount of sunlight for safe solar projection. Big-scope owners might consider cutting a 2-inch hole in a cardboard mask, then placing it over the front of the scope. To project the Sun's image, simply insert a low-power eyepiece (a Ramsden or Huygenian is recommended) into your scope and aim sunward. You're on target when the shadow of your telescope tube is round and bright light illuminates the eyepiece. A piece of white paper or cardboard held about a foot from the eyepiece should pick up a circle of light (the Sun's disk). Focus until the circle is sharp at the edges. If you must view the Sun directly, or own expensive eyepieces that might be cooked by the solar projection method, consider purchasing a so-called aperture filter that fits over the top of the tube and intercepts excess light and heat before it enters your scope.

Take a good look at the Sun's disk, and it you'll see that it appears a little darker around the edges — a phenomenon called limb darkening. Most obvious are the sunspots. These relatively cool surface regions of the Sun are fascinating to study. Day by day, sunspots evolve, grow, and subside. They also move across the solar disk, carried along by the Sun's rotation. Sunspot numbers rise and fall in an

## A Solar System Arsenal

What's the best optical system for capturing solar system objects? Actually, no single telescope or observing device has a lock on the Sun and its family. Here are some recommendations.

**Naked eye**. Best for studying Moon phases, motions of the Moon and planets through the constellations, meteors and meteor showers, aurorae; adequate for solar and lunar eclipses, lunar occultations of bright planets and stars.

**7x50 binoculars**. Best for bright comets; adequate for the Moon, lunar occultations. Provides many fun evenings of simple viewing.

**Small telescope**. (60mm refractor or 3-inch reflector). Best for solar observations (follow safety precautions), bright comets; adequate for all planets (except Pluto), minor planets brighter than 10th magnitude.

**Medium-sized telescope.** (6-inch f/8 reflector). Best for general lunar and planetary observations, lunar eclipses and occultations, asteroids brighter than 12th magnitude, faint comets; adequate for solar observing (use an aperture mask if projecting the Sun's image), bright comets.

**A 4- to 6-inch refractor**. Best for detailed lunar and planetary observing, occultations by the Moon and asteroids; adequate for bright comets (will show nuclear detail).

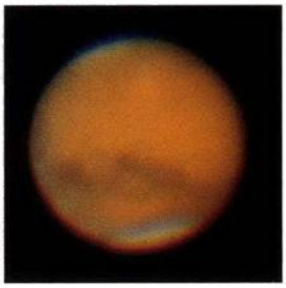
**A 12-inch or larger reflector**. Best for faint comets and minor planets; adequate for lunar and planetary observations (when used with an off-axis mask).

J. T. Howell

**Tiny, Elusive Mercury**

Charles F. Capen

**Venus' Bright, Gibbous Disk**


Donald C. Parker

**The Dusky Globe of Mars**

11-year cycle. In recent years, the Sun has been in the down part of this cycle, its disk relatively spotless. But the tide has turned, and in 1997, you should see some sunspots. A few years from now, the Sun will again be in peak activity, its surface littered with these dark blotches.

If money is no problem and you really want to view the Sun up close and personal, invest in a hydrogen-alpha filter. An ideal accessory for a medium to large aperture scope, a hydrogen-alpha filter reveals intricate detail in the Sun's surface, especially around sunspots. You'll also get magnificent views of prominences, those huge gas loops otherwise visible only during total solar eclipses.

### The Planets

The planets are great telescopic targets, because they offer immediate visual rewards to the beginner and skill-testing observational challenges to the expert. Mercury is a rewarding telescopic target just because of its elusive nature. Its image in the telescope is poor at best, because Mercury is usually so low in the sky, atmospheric turbulence badly distorts its image. Most telescope owners will be happy just to see Mercury's half-moon appearance around elongation.

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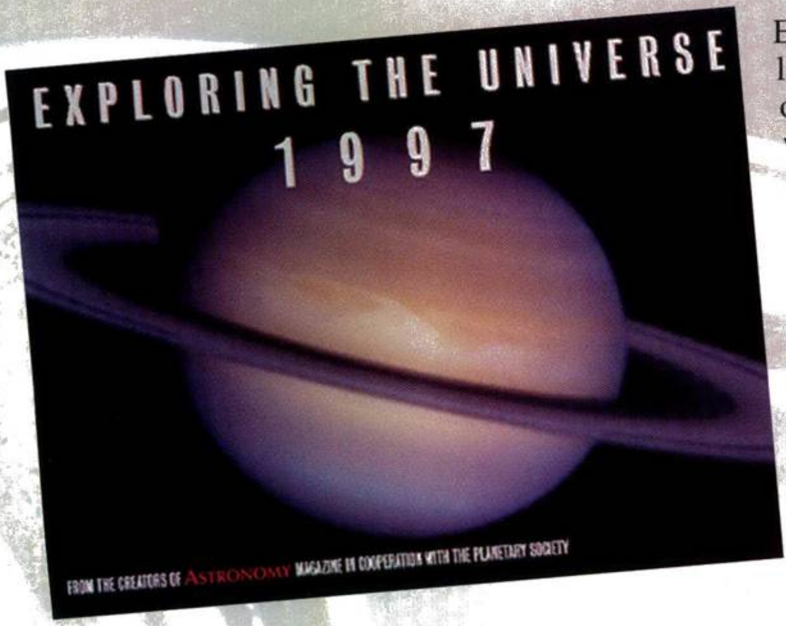
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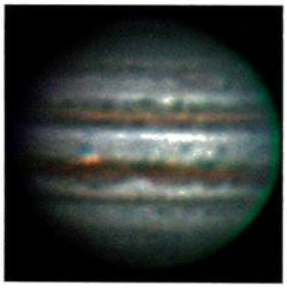
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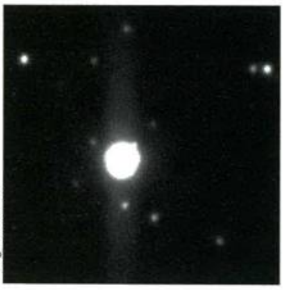
**Jupiter's Cloudy Bands**

Donald C. Parker

**Saturn's Rings**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**Uranus and Its Moons**

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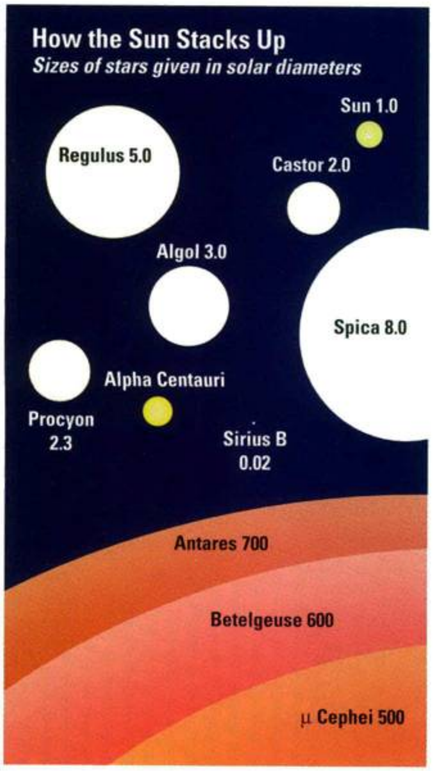
**The Frozen Globe of Pluto**


**How the Sun Stacks Up**

*Sizes of stars given in solar diameters*

ASTRONOMY: Lee Vande Visse

If you're a Venus fan, 1997 is unfortunately an off-year. For several months before and after an April 2 conjunction with the Sun, Venus appears unfavorably low in the sky. Only from mid-October to late December will Venus be well-positioned above the western horizon after sunset. Through the telescope, you'll see a featureless white disk. Venus is forever veiled by a dense cloud cover. What makes Venus an interesting telescopic sight (and astounded the pioneering astronomer Galileo, when he viewed Venus nearly four centuries ago) are the moonlike phases it goes through as it circles the Sun. Reenact Galileo's historic observations by observing Venus once every week or two during its late-autumn appearance.

Mars can be as elusive as Mercury, but for a different reason. Oppositions that bring the Red Planet close to Earth occur just once every 2½ years. Even then, some oppositions (like the one slated for March of this year) aren't too favorable. Mars is the only planet whose surface features may be studied with the telescope. Obvious this year will be the north polar cap and dark markings on the otherwise yellow-orange disk. You can enhance the contrast by using a #25 red filter. Even a filter can't counteract the turbulence in our atmosphere that scrambles the Martian image. Now and then, the air settles and an incredible wealth of detail becomes visible. As your eyes strain to take it all in, the turbulence returns. Observing Mars requires patience.

Arguably the best planet for telescopic studies (and a definite eye-catcher when it arrives at midsummer opposition in 1997) is Jupiter. Even at its distance of nearly 650 million km, it presents a big target. A magnification of just 25x–30x reveals Jupiter's slightly flattened, pale-yellow disk, traversed by several grayish brown cloud bands. Large telescopes and magnifications of 150x or more bring out a wealth of detail in the belts, especially when Jupiter is viewed through a filter (a #80A light blue works well). The Red Spot, that famous Earth-sized hurricane, may also be glimpsed. Especially eye-appealing are the four bright satellites that flank the big planet. As they orbit edge-on to our line-of-sight, these moons swing from one side of Jupiter to the other. Eclipses of these satellites are fun to watch; their times are listed in each current issue of ASTRONOMY.

The telescopic gem of the solar system is the ringed planet Saturn. No other object, except perhaps the Moon, evokes more excitement from first-time viewers. We can only guess how many active astronomers were inspired to their lifelong pursuit of the heavens after a telescopic visit to this world. In 1997 Saturn will be most accessible from mid-autumn (opposition is on October 10) until year's end.

## Our Enemy Atmosphere

We live under an atmospheric ocean. Like its watery counterpart, the air overhead ebbs and flows and wreaks havoc on the light passing through it. Two characteristics of the atmosphere affect skygazing. The first, its transparency, is governed by the amount of haze or dust present in the air. You can judge the transparency by the faintness of the stars visible to the unaided eye. Under ideal dark-sky conditions, you can glimpse 6th, even 7th, magnitude stars. A light haze will reduce that limit to 5th magnitude. Under heavy haze, even bright stars will be hard to see.

A second sky characteristic is the atmospheric seeing, or steadiness. If the seeing is good, stars shine steadily. Poor seeing means turbulent skies and stars that twinkle like crazy. It is a rare night, indeed, when the transparency and seeing are ideal. When one is favorable, the other usually isn't. Astronomers learn to play with the hand they're dealt. If the transparency is good, check out sky objects (like comets and deep-space objects) whose faint detail will be well-seen. If the seeing is good, go for high-power views of the Moon and planets or close double stars.

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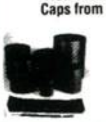

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Preston S. Justis

Asteroid 4179 Toutatis (triple exposure showing motion)

Two years ago, the rings were edge-on and all but invisible. Now they've opened up, and can be glimpsed through the smallest of telescopes. Small scopes will also capture the giant moon Titan, which appears as a tiny star next to Saturn. Several other moons can be viewed with larger scopes. Their positions are charted each month in ASTRONOMY.

The "twin" gas giants Uranus and Neptune require optical aid to be seen (at magnitude 5.7, Uranus is a marginal naked-eye object). Both are accessible with binoculars and are easily seen with small telescopes. A finder chart on page 56 show the way to these blue-green giants. Both planets reach opposition in late July (the 29th for Uranus, the 21st for Neptune), so summer is the season to track them. On the night you're observing, look for a "star" in the area where your target planet is supposed to be. Check back a few nights later to verify your suspect's motion. You can actually confirm your sighting of Uranus immediately. Though more than two billion km away, Uranus sports a small disk, which may be glimpsed with 100x or more. Neptune's tiny disk — the apparent size of a penny over one km away — belongs to a large telescope with superior optics.

A large telescope is also your only ticket to the solar system's ninth planet, Pluto. It's possible to glimpse this 14th magnitude world in a 6-inch scope, but twice that aperture is more practical. As with Uranus and Neptune, finding Pluto requires a good map (see ASTRONOMY). Your best opportunity for success is between late May and mid-July, when Pluto is near opposition.

### Solar System Debris

Minor planets, commonly referred to as asteroids, are hardly telescopic showpieces. Appearing as starlike specks, they are nonetheless actively pursued by a dedicated band of amateur astronomers. What's the draw? Perhaps it's the joy of seeing how many of these tiny worlds you can notch with your scope (over a hundred are within the grasp of a 3-inch telescope). In some cases, it's the opportunity to make an honest contribution to science. Periodic variations in an asteroid's brightness, picked up by amateurs using sensitive CCDs, will uncover its rotation period. Teams of amateurs, observing an occultation of a star by an asteroid, have gained valuable insights into that asteroid's size and shape. ASTRONOMY often features some of the currently-observable asteroids.

We've already mentioned that 1997 is the year of Comet Hale-Bopp. This brilliant visitor will attract the attention of telescope owners around the world. And why not? Brilliant comets like this are a once-a-decade proposition. Hyakutake made a spectacular performance just last year, but the previous comet splash was made by

**An Observer's Guide To Comet Hale-Bopp**
When and where to see it, and what to look for
by Don Machholz

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An 84-page guide describing comets and Comet Hale-Bopp in particular, this book provides observing hints, suggests special projects, and uses 60 maps to help anyone find the comet on any night through 1988.

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**CLASS "B"**
Color band - white. Class "B" filters are made with polished glass and multi-alloy coating. These filters offer great durability and will provide many years of service and enjoyment with normal use. Can be used visually and for photography. Light transmission is 1/100th of 1%.

**CLASS "C"**
Color band - red. Class "C" filters are specifically coated to a lighter density (ND-4). They are for photographic use only. This filter is intended for use by professionals and serious hobbyists. Light transmission is 1/100th of 1%.

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1. State scope brand and model number, aperture and outside diameter with filter class and price.
2. Make check or money order payable to J.M.B. Inc. All foreign checks must be payable through a U.S. bank.
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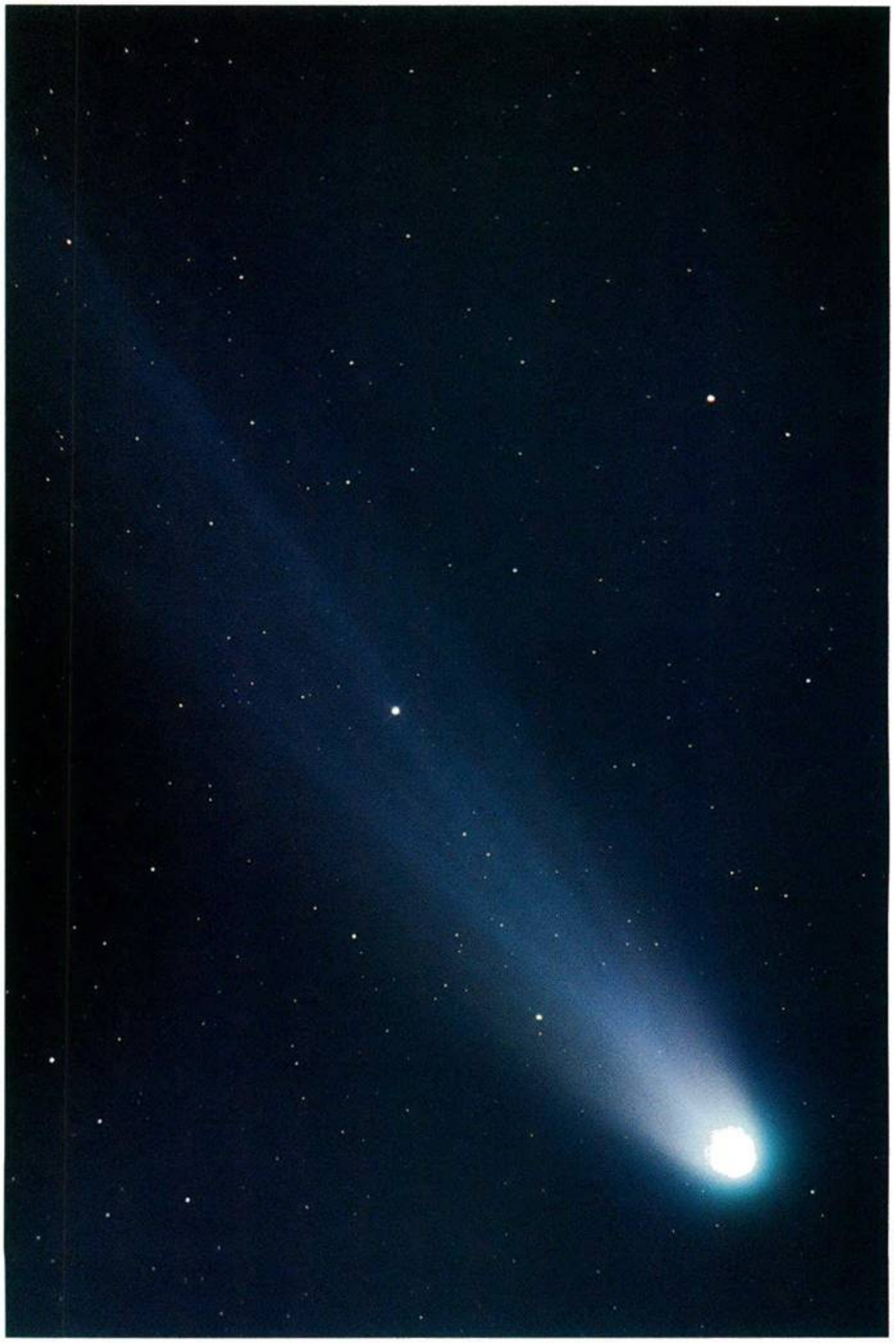
Comet West back in 1976. Fortunately for comet lovers, about a dozen of these icy mudballs streak through the inner solar system each year; most are rather dim and unheralded. A few are bright enough to be glimpsed with binoculars or small scopes. The rest require larger instruments. To keep abreast on the whereabouts of any currently-observable comets, check each issue of ASTRONOMY. For now, enjoy Hale-Bopp.

Meteors are not good telescopic targets. How many times has a telescope owner peered intently at some distant galaxy when a companion, gazing skyward while waiting his turn at the eyepiece, shouted loudly at the sudden appearance of a bright meteor? The telescope owner looked up, and, nothing. If you're patient, you might aim your telescope 20° or 30° from the radiant of a major meteor shower and catch a fleeting glimpse of a few faint shower members. Check our list of major annual showers in the first section and good luck. □

**Comet Hyakutake**



Dennis Sørensen

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| Pronto 70mm f/6.4 apochromat w/2" diagonal | $939 |
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| **NEW! Bino Vue** binocular viewer | $899 |
| Gibraltar mount with ash wood tripod | $495 |
| **7.4, 10.4, 13, 17, 21, 26mm Plossl** 50° | $79 |
| 8, 11, 15mm Plossl **$89**, 20, 25mm | $99 |
| **32mm Plossl**, widest true field in 1¼" | $119 |
| **55mm 2" Plossl**, widest possible field | $229 |
| **2.0x or 3.0x Tele Vue Barlow Lens** | $115 |
| **2" Giant Barlow - 2x** | $179 |
| **15mm Wide-Field**, 1¼" eyepiece, 65° | $139 |
| **19mm Wide-Field**, 1¼" eyepiece, 65° | $149 |
| **4.8mm Nagler**, 82° field, 1¼" eyepiece | $169 |
| **7mm Nagler**, 1¼" eyepiece, 82° field | $219 |
| **9mm Nagler**, 82° field, 1¼" or 2" | $239 |
| **13mm Nagler**, 82° field, 1¼" or 2" | $299 |
| **12mm Nagler**, Type II, 82°, 1¼"/2" | $279 |
| **16mm Nagler**, Type II, 82°, 1¼"/2" | $299 |
| **20mm Nagler**, Type II, 82°, 2" only | $375 |
| **1¼" Paracorr Visual Coma Corrector** | $159 |
| **2" Paracorr Visual Coma Corrector** | $249 |
| **15mm Panoptic 1¼"**, 68° field | $209 |
| **22mm Panoptic 1¼"/2"**, 68° | $269 |
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The LUMICON adjustable piggyback mount is ideal for telescopes of 6-16" aperture. It permits **both** vertical and sideways adjustment for optical alignment. Also ideal to mount LUMICON 80mm SUPER-FINDER™, large telephoto lenses and small telescopes up to about 5 lbs.
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***"The LUMICON O-III proved to be our favorite... It gave the greatest contrast gain."*** ***ASTRONOMY*, February 1991**

### AMAZING O-III FILTER™

**Helix Nebula, NGC 7293 in Aquarius. Bright and easy with Lumicon Oxygen-III Filter.**

**GREATLY ENHANCED DETAIL**

*"Consistently performed well on all emssion and planetary nebulae. Detail and structure were greatly enhanced in the more than two dozen objects I viewed."* ***SKY & TELESCOPE*, July 1995**

**BETTER THAN A DARK-SKY SITE!?**

*"From my light polluted backyard, the view .... was better with the O-III than with any other filter tested. The view was even better than without the filter from a dark-sky site."* ***SKY & TELESCOPE*, July 1995**

### SEE THE HORSEHEAD!

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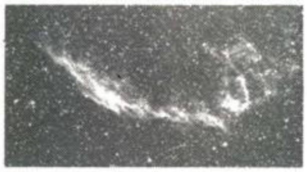

**"I CAN SEE THE VEIL NEBULA!"**

Rich Zepernick saw the Veil Nebula for the very first time with a **LUMICON UHC Filter**. He stated, *"It was actually there! and not just around 52 Cygni, but the whole loop! Words cannot possibly express my feelings. I don't know how I managed without these filters."*
**Rich Zepernick, Cresskill, NJ**

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*"Based on our tests we'd recommend a LUMICON Deep-Sky and Oxygen-III as complementary filters. The LUMICON Deep-Sky Filter clearly had the best contrast for **reflection** nebulae."* ***ASTRONOMY*, February 1991**

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| **72mm LUMICON Giant DEEP-SKY Filter** (62, 67, 77mm adapter, $10, 82mm $16) | $299.50 |
| **2" Rear Cell Filter,** fits SCT's Deep-Sky, **$119.50** UHC, O-III, H-Beta, | $199.50 |
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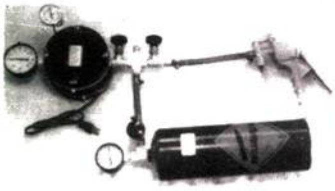

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| NEWTONIAN EASY-GUIDER | **$189.50** |
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GIANT EASY-GUIDER ..... **$395.00**
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Lumicon 12mm eyepiece system has adjustable LED illumination, dual crosslines, pulsed.

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4. **Dual-axis drive corrector** for telescope. This should be part of the telescope when purchased. Call LUMICON for details.

5. **LUMICON EASY-GUIDER** (selection to left) .

6. **LUMICON 48mm DEEP-SKY FILTER $119.50**
This is essential for highest possible contrast. Contrast is boosted up to 3X for ***both*** color or black & white photos. The 3 photos in this ad showing the Helix Nebula, Horsehead Nebula and Veil Nebula were all made using a LUMICON 48mm DEEP-SKY FILTER.

7. **Hypersensitized film.** Purchase from LUMICON or make your own with a LUMICON HYPER-KIT.

### HYPERSENSITIZED FILM

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***HYPERED FILM IS 2-10X FASTER!***

LUMICON Hypersensitized film is essential for good deep-sky astrophotography. Deduct 10% for 3 or more rolls (mixed o.k.). ***No C.O.D.s.***

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# And Out into the Universe

When you look up at the nighttime stars, your gaze carries you far beyond the constraints of the solar system. Stars are the most obvious and numerous inhabitants of deep-space. Thousands greet the unaided eye — a number multiplied tenfold with the help of a standard pair of binoculars. With telescopic aid, the visible population of stars rises astronomically, literally. A 6-inch reflecting telescope can capture in excess of two million stars. And why not? Its objective mirror collects over 600 times as much light as the eye alone.

One of the most disappointing sights to the novice is the sight of a star through a telescope. No matter what magnification, all that appears is a tiny speck of light. On closer inspection, a star's image provides important information about the quality of a telescope's optics and the condition of the night air. But it's still just a speck, only much brighter — and often more colorful. When stars are made brighter, their colors come to light. The star Mu (μ) Cephei, an unspectacular naked-eye speck, becomes a vivid red drop of blood.

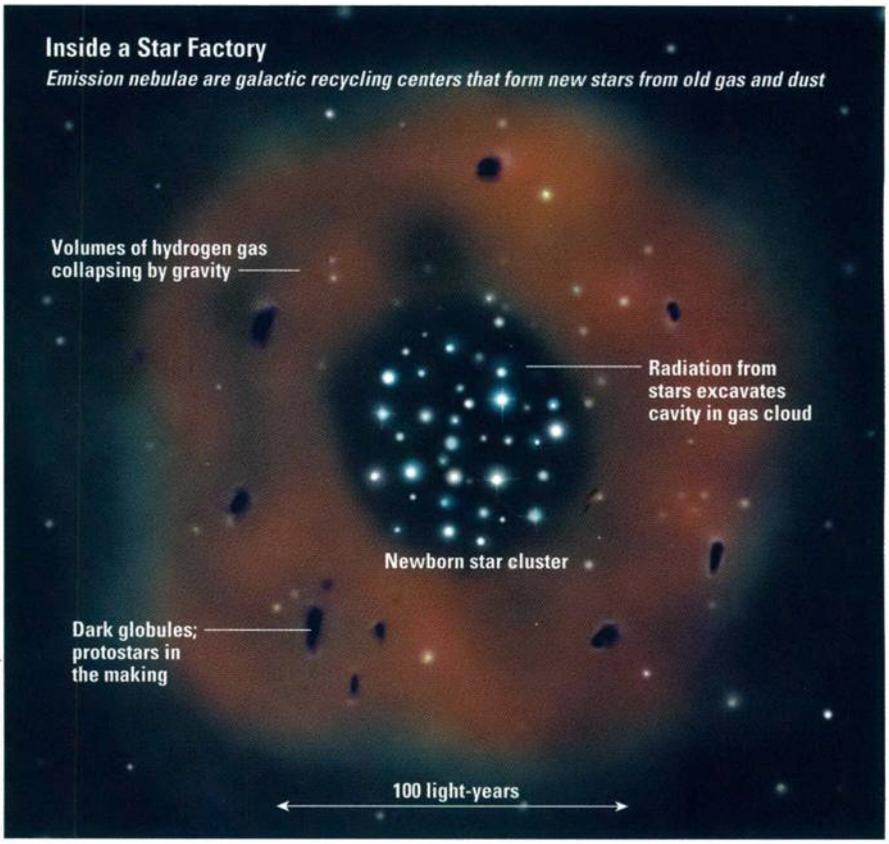
## Variable Stars

The telescope is a vital tool in the study of those stars that change in brightness. It is variable star observing that offers backyard astronomers the opportunity to make major contributions. Far too many variable stars exist for professional astronomers to monitor, and making a brightness estimate of a variable star requires little equipment and a minimum of practice. All you need is the appropriate optical aid (some variable stars can be observed by the unaided eye, many more with binoculars, and the vast majority with telescopes of any size) and a chart showing the magnitudes of nearby field stars. By comparing the variable with field stars of comparable magnitude, you can estimate its brightness to an accuracy of 0.3 magnitude.

If you've never studied a variable star before, try S Cephei. A pulsating variable star that varies between 7th and 12th magnitudes in a 487-day cycle, S Cep is noted for its vivid red color. Its north circumpolar location and relatively bright range make it available year round to telescopes of all sizes. Use our finder chart to locate S Cep and estimate its brightness. S Cep has a long cycle, so an observation every two weeks will suffice. The vivid red color of S Cep makes it appear brighter than it really is. To counteract this effect, rack the field out of focus before making your estimate.

**Inside a Star Factory**

*Emission nebulae are galactic recycling centers that form new stars from old gas and dust*


Volumes of hydrogen gas collapsing by gravity
Radiation from stars excavates cavity in gas cloud
Newborn star cluster
Dark globules; protostars in the making
100 light-years

ASTRONOMY: Elisabeth Rowan

**The Summer Milky Way**

Jerry Schad

### Double and Multiple Stars

Albireo (Beta [β] Cygni), is an ordinary 3rd magnitude star — until you gaze upon it with a telescope. Suddenly, one of the loveliest sights in the night sky appears. A bright golden-yellow star lies adjacent to a sapphire blue partner. Double stars are numerous beyond belief. Indeed, more than 50 percent of all stars are doubles, triples, or multiples. Alpha (α) Centauri, our nearest star, is a triple system. Sirius (Alpha Canis Majoris), the brightest nighttime star, is a binary.

A description of a double star includes three pieces of information: the magnitudes of the component stars, their angular separation in arcseconds (") and the position angle. (One arcsecond equals 1⁄3600th of a degree, the apparent width of a penny 2½ miles away.) Position angle describes the position of the fainter component relative to the primary, and is measured counterclockwise from north (0°) toward the east (90°). For Albireo, the stats read: magnitudes 3.2 and 5.4, separation 34.3", p.a. 54°. Knowing a double star's magnitudes and separation give you a clue as to its visibility in your telescope, while the p.a. helps locate an extremely faint companion.

The charm of double stars lies in their simplicity, just two stars side-by-side. An endless possibility of magnitudes, colors, and separations makes each double star unique. Besides Albireo, try the colorful pairs Gamma (γ) Andromedae (2.3 and 5.1, 10.0", 63°, gold and blue); h3945 Canis

Michael Stecker

**Star Cloud M24**

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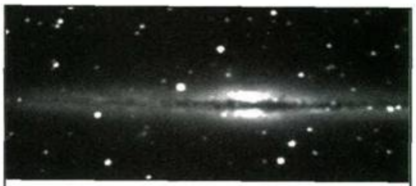

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Majoris (4.8 and 6.8, 26.6", 55°, gold and blue), Eta (η) Cassiopeiae (3.6 and 7.5, 12.0", 307°, yellow and red), and Xi (ξ) Bootis (4.8, and 6.9, 334°, yellow and red). Not so colorful, but beautiful to behold are Mizar (Zeta [ζ] Ursae Majoris), (2.4 and 4.0, 14.4", 151°), Cor Caroli (Alpha Canum Venaticorum, (2.9 and 5.4, 19.6", 228°), Gamma Leonis (2.6 and 3.8, 4.3", 123°), Beta Scorpii (2.9 and 5.2, 13.6", 24°), and Gamma Delphini (4.5 and 5.5, 10.0", 268°). Try your luck finding the faint companions to Polaris (Alpha Ursae Minoris), (2.0 and 8.8, 18.4", 218°) and Rigel (Beta Orionis), (0.1 and 6.7, 9.4", 202°). And don't forget the grand twin system Gamma Arietis (4.8 and 4.8, 7.8", 359°) and the "double-double" Epsilon Lyrae (5.0 and 6.0, 2.8", 359°

William Yang

**Globular Cluster Omega Centauri**

## A Deep-Sky Arsenal

The following lists the best uses for the various viewing packages available. Any optical device can be used on a wide variety of sky objects, but some systems are better suited than others

**Naked eye.** Best for all-sky views of constellations, Milky Way, and variable stars brighter than 5th mag.; adequate for bright star clusters.

**7x50 binoculars.** Best for large star clusters (Pleiades) and nebulae (North America Nebula), moderately bright variable stars (mags. 5–7); adequate for globular clusters, wide double stars.

**Small telescope** (60mm refractor or 75mm reflector). Best for bright, wide double stars, bright star clusters, variable stars between mags. 7 and 10; adequate for globular clusters, moderately bright galaxies.

**Medium-sized telescope** (6-inch f/8 reflector). Best for general views of deep-space objects, close double stars; adequate for large nebulae and galaxies.

**A 4- to 6-inch refractor.** Best for close double stars, compact star clusters, planetary nebulae; adequate for large nebulae and galaxies.

**A 12-inch or larger reflector.** Best for faint clusters, nebulae, and galaxies, variable stars from 9th to 14th mag. or fainter; adequate for double stars, planetary nebulae.

and 5.1 and 5.4, 2.2", 98°, the pairs just 208" apart). All of these double stars are within the reach of small telescopes.

Less common, but certainly no less interesting are triple and multiple stars. Set your sights on Iota (ι) Cassiopeiae (4.7, 7.0, and 8.3, 2.4" and 7.3", 235° and 114°), Beta Monocerotis (4.5, 5.2, and 5.6, 7.3" and 10.0", 132° and 124°), and the crown jewel of the Orion Nebula, Theta$^1$ ($\theta^1$) Orionis (5.4, 6.8, 6.8, and 8.0, 13.3", 13.1", and 16.8", 61°, 311°, and 342°).

Close binary systems are important to professional astronomers because their gravitational interactions provide a way to determine stellar masses. Careful observations of a binary star, made over a period of many years or decades, allow astronomers to compute its orbital elements, and the masses of the component stars. Because of their great numbers, binary stars pose the same problem for the professionals that variable stars do. Again, opportunity awaits backyard astronomers to make valuable contributions to the professional community, this time by measuring the separation and position angle of the binary pair. However, measuring a binary star is more complicated and time-consuming (and expensive) than estimating the brightness of a variable star. To do the job correctly requires a large, motor-driven telescope, and a micrometer to measure separations and position angles. Notable close binaries currently undergoing rapid changes include 70 Ophiuchi (4.2 and 6.0, 3.0", 158°, separation increasing, position angle decreasing; Period = 88 years), Gamma Virginis (3.5 and 3.5, 2.3", 275°, sep. and p.a. dec.; 171 years), and Castor (Alpha Geminorum), (1.9 and 2.9, 3.6", 64°, 500+ years).

### Star Clusters

Double and multiple stars are the gems of the nighttime sky. Gaze at a star cluster, however, and you've captured the whole treasure chest. Two types of star clusters, open and globular, inhabit our Galaxy. Perhaps the best-known open star cluster is M45, better known as the Pleiades, or Seven

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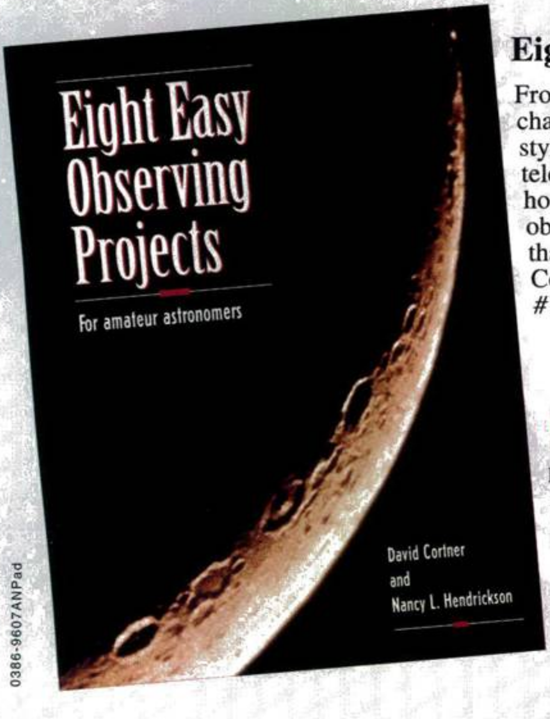

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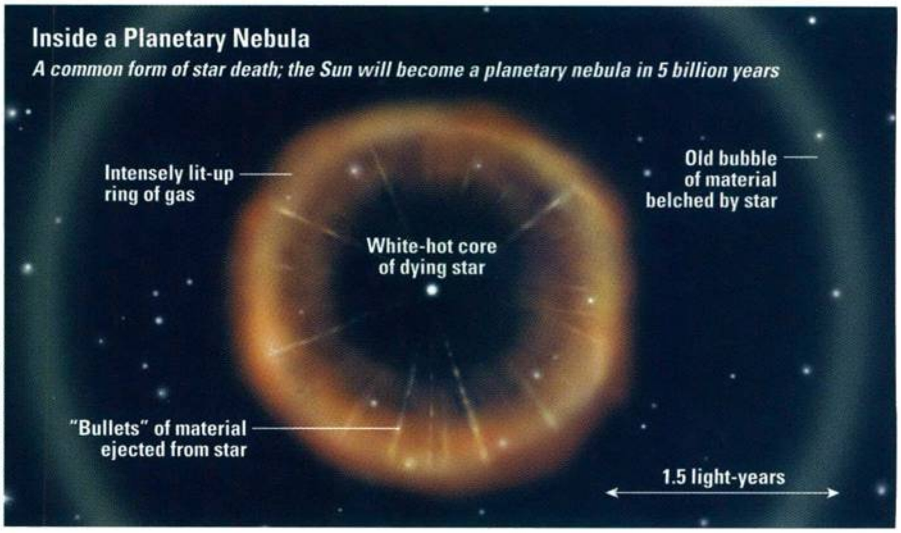
Gerald Rhemann and Franz Kersche

**The Horsehead Nebula**

William Yang

**The Eta Carinae Nebula**



**Inside a Planetary Nebula**

*A common form of star death; the Sun will become a planetary nebula in 5 billion years*

Intensely lit-up ring of gas
Old bubble of material belched by star
White-hot core of dying star
"Bullets" of material ejected from star
1.5 light-years

ASTRONOMY: Elisabeth Rowan

Sisters. The unaided eye sees a half dozen Pleiads arranged like a tiny dipper. Viewed with optical aid, the naked-eye Pleiads are joined by dozens of fainter cluster members. This is a typical star count for an open cluster. Open clusters are born in the gas-rich spiral arms of our Galaxy, so most appear in or near the Milky Way. Their stars are infants; indeed, many open clusters still carry faint traces of the nebulosity that spawned them. Other showpiece open clusters include M44 (the Beehive in Cancer), M41 in Canis Major, M35 in Gemini, and the Double Cluster (NGC 869 and NGC 884) in Perseus.

As rich as open clusters may seem, they pale when compared with globular star clusters. These spherical swarms contain as many as one million stars, many in the latter stages of stellar evolution. M13 in Hercules is typical of the Galaxy's 130 known globulars. Remotely situated with its kindred globulars in a halo centered on the core of our Galaxy, M13 is an unresolved blob of light in binoculars

Tony and Daphne Hallas

The Nebulae of Central Cygnus

Bill Iburg

The Crab Nebula

and small scopes. But viewed with a 6-inch or larger telescope, M13 is an incredible sight — a handful of sparkling sugar grains heaped upon a sheet of black velvet. That's the visual appearance of other globulars like M22 in Sagittarius, M3 in Canes Venatici, M5 in Serpens, and M4 in Scorpius.

## Nebulae

Nebulae represent the essence of star formation. Emission nebulae are the contracting gas clouds from which stars are born. Dark nebulae are sheets of interstellar dust. Planetary

Andrew Peters

Open Cluster NGC 3293 and Emission Nebula NGC 3324

George Greaney

Emission Nebulae IC 405 and IC 410 in Auriga

John Chumack

**The Dumbbell Nebula**

nebulae are huge cosmic puffballs created by dying stars.

Arguably the finest emission nebula in the entire sky is M42, the Orion Nebula. Its location in a bright constellation that straddles the celestial equator makes it an easy target, accessible virtually any place on the planet. A fuzzy patch of light to the unaided eye and binoculars, the Orion Nebula comes alive when viewed through the telescope. Wreaths of luminous gas branch out like wings of some cosmic eagle — an awe-inspiring sight in small and large telescopes. Gaze at this magnificent glowing cloud and you'll almost sense the star creation going on inside it. Bright emission nebulae are relatively uncommon, but two especially fine examples reside in Sagittarius: the Lagoon Nebula (M8) and the Omega Nebula (M17). Like the open star clusters they ultimately form, emission nebulae and dark nebulae are concentrated along the plane of the Milky Way.

In its final death throes a star may eject a shell of gases or, if massive enough, explode violently. In either case, the expanding mass of gas forms a nebula that remains illuminated by the remains of the dying star. Planetary nebulae, as the name implies, have a disk-like appearance. As one

Tim Hunter and James McGaha

**Spiral Galaxy M83**

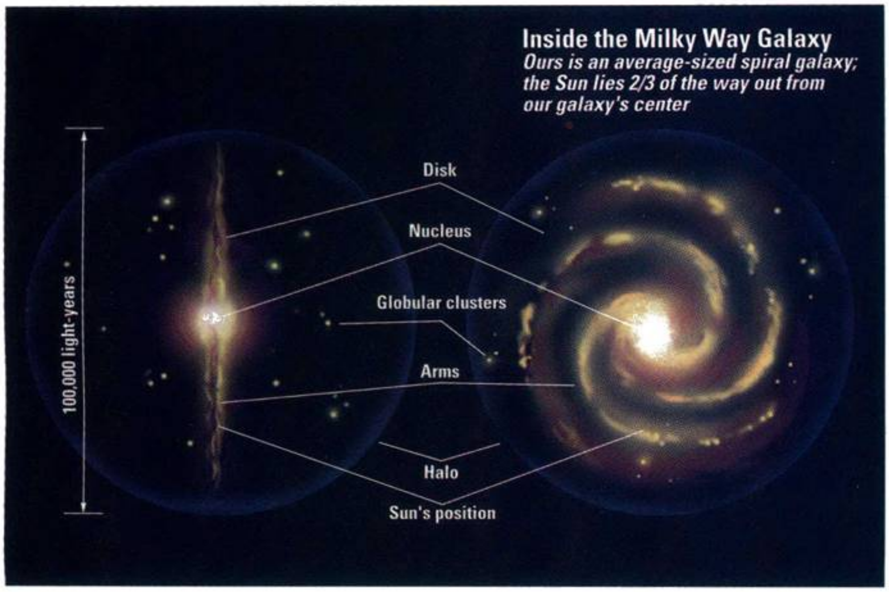
astronomer aptly put it, planetary nebulae are "wreaths placed by nature around dying stars." The best planetary nebulae for modest telescopes are M1 (the Crab Nebula) in Taurus, M27 (the Dumbbell Nebula) in Vulpecula, M57 (the Ring Nebula) in Lyra, and NGC 7009 (the Saturn Nebula) in Aquarius.

Want to see nebulae and other relatively faint deep-sky objects more clearly? There are two ways you can do it. One is to view the nebula with a sideward glance, a technique called "averted vision." Averted vision allows faint light to strike a more sensitive part of the retina. Look directly at the nebula — nothing. Look slightly to the side and, voila, there it is. Another way to enhance your view of deep-sky objects is with a nebula filter. Several designs exist, each with a special purpose. Some filter out stray light (light pollution), making the nebula more visible. Others filter out all but a certain wavelength of light common to the class of deep-space object being observed. The O-III filter works well on planetary nebulae, while UHC filters brings faint emission nebulae to light.

## Galaxies and Quasars

Galaxies are the night sky's cerebral deep-sky objects. Largely unspectacular in the telescope, their attraction lies in the observer's awareness and appreciation of what he or she is seeing. Understand that you're looking at a mass of billions of stars so remote that its light has been traveling through space for millions of years, and that smudge of light becomes very interesting. So enormous are galaxies that, even at their incredible distances, they appear large. The Andromeda Galaxy (M31), for example, appears as an elliptical blob bigger than the Full Moon. It's easily seen with magnifications as low as 20x–30x. This galaxy, along with our Milky Way, the Magellanic Clouds, M33, and other galaxies, form a small cluster called the Local Group. But the real galaxy gazer's playground is in a region of sky between the constellations Coma Berenices and Virgo. This is the so-called Realm of the Galaxies, home to thousands of these island universes. You'll need a good chart to find your way around there. As you wander from one fuzzy patch to another, you'll gain an awareness of the vastness of our universe. You may even wonder if someone out there is looking back.

An often-asked question about telescopes is how far they can see into space. The answer is incredibly far. For medium to large-aperture scopes, the ultimate deep-sky objects are quasars. Quasars are even more cerebral than galaxies, because all you'll see is a tiny starlike image. The closest quasar, 3C 273, is located in Virgo. A harmless-looking 12th magnitude "star," 3C 273 is in reality the active nucleus of a galaxy one billion light-years away. When you look at this quasar, the light falling on your retina



**Inside the Milky Way Galaxy**

*Ours is an average-sized spiral galaxy; the Sun lies 2/3 of the way out from our galaxy's center*

Astronomy: Phil Kirchmeier

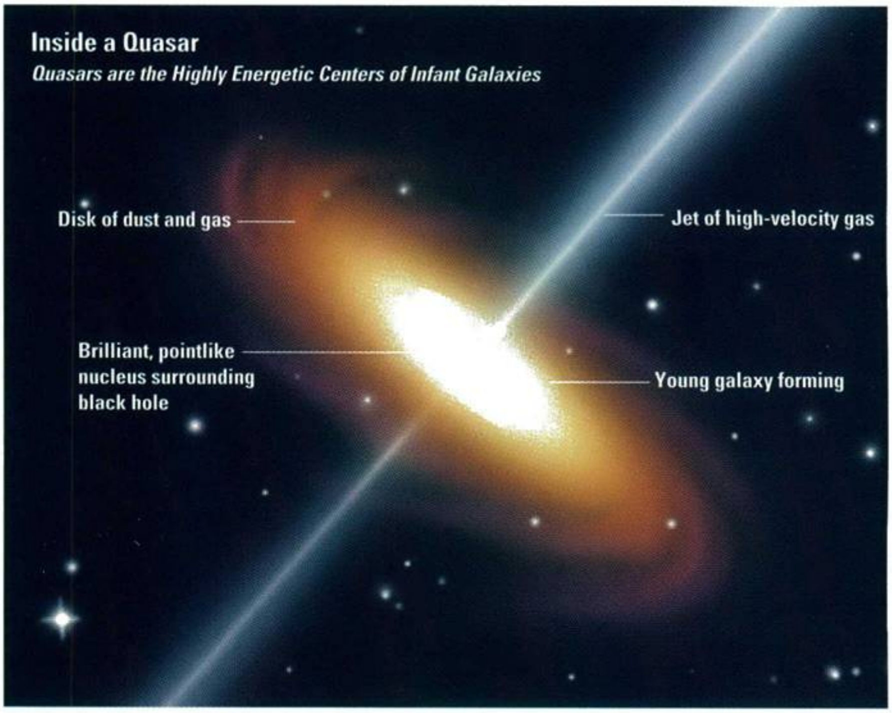
Jason Ware

**Edge-on Galaxy NGC 4565**

left at a time when the Earth's surface was essentially barren of life, and the most highly-evolved creatures in the ocean were bacteria and algae.

Most of the bright, showpiece clusters, nebulae, and galaxies are listed in the Messier catalog. This historic compilation of 100-plus deep-space objects is the work of the 18th century French comet-hunter Charles Messier. Tired of false alarms caused by sky objects that looked like comets in his telescope, Messier began to catalog these nuisances.

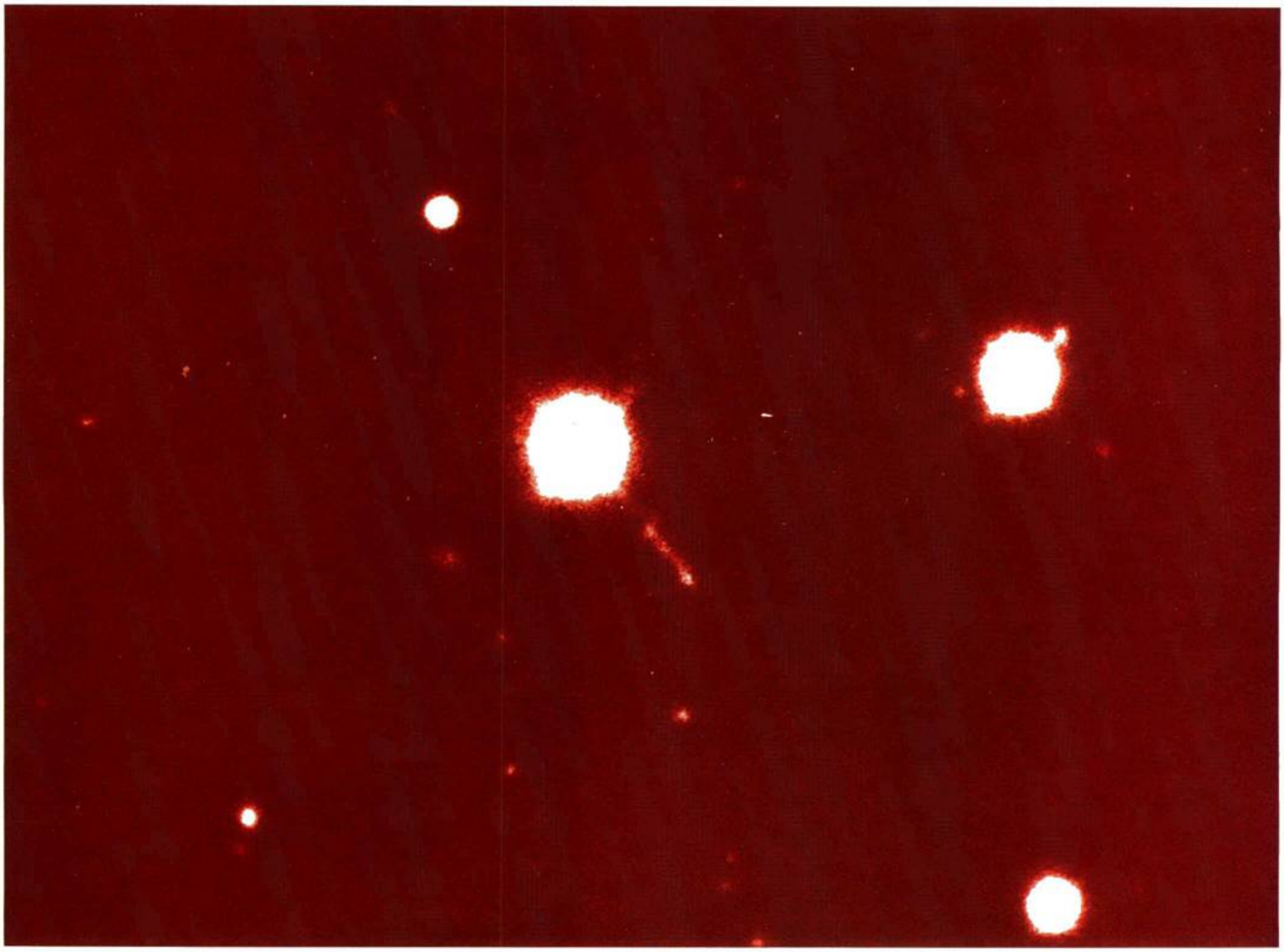
Today, hundreds of thousands of amateur astronomers eagerly pursue the so-called Messier objects, because many rank as the sky's finest deep-space sights. Messier's telescopes were small and optically crude by today's standards. You can notch his entire catalog with a 3-inch telescope, as long as you have a light-free observing site. ☐


**Inside a Quasar**

*Quasars are the Highly Energetic Centers of Infant Galaxies*

Disk of dust and gas
Jet of high-velocity gas
Brilliant, pointlike nucleus surrounding black hole
Young galaxy forming

ASTRONOMY: Elisabeth Rowan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**Quasar 3C 273**

# Sharing the Stars

Amateur astronomy is often a solitary activity. Unless you have a friend or relative who lives nearby and shares a passion for exploring the heavens, you're out there on your own night after night. The solitude of an evening's skygazing is good for the soul, but occasions will arise when you'll want to share your astronomical experiences with others.

You may be eager to compare notes on last night's eclipse. Perhaps you're wondering how an eyepiece advertised in ASTRONOMY would perform with your telescope. If so, it's time to become astronomically social. Here are several ways to get into the cosmic mainstream.

## Party with the Stars

There's an almost magical atmosphere that surrounds an astronomy gathering. The enthusiasm you feel for astronomy is there a dozen, a hundred, a thousand or more times over. Amassed in one place is a legion of people from all walks of life who share a single bond with you — they are as fascinated by the night sky as you are. What a pleasure to be able to talk astronomy to just about anyone in sight, and know you'll have a receptive audience.

Most star parties and astronomy conventions feature talk sessions that include a variety of topics geared to all levels of experience. Find out how to locate and observe sky objects with that 60mm refractor you just bought. Learn how to test the 8-inch f/8 mirror you're grinding. Discover the latest CCD techniques. And should you fail to find your answer in the talk session, you'll probably bump into a fellow convention-goer who has the knowledge you seek.

A popular mainstay of many conventions is the swap table. All sorts of astronomical goodies, from binoculars to telescopes and their accessories to atlases and handbooks, will be available. Optical goods like telescopes and eyepieces retain their original condition, if properly cared for. At a swap table, you can purchase much-needed equipment in excellent condition for a fraction of the retail cost.

Herbert Hirsch

**A Star Party in Lockwood Valley, California**

If an astronomy convention has observing at night and sky conditions are favorable, you're in for a memorable evening. Silhouetted against the darkness are telescopes — lots of them. Lines of eager skygazers queue up at each. The air is abuzz with conversations about favorite sky objects, the best ways to observe them, and with what. As you wait in line, you're getting an education in amateur astronomy. A bright meteor blazes across the sky. Back home, you would have watched silently for fear of disturbing the neighbors. Here, you cheer and applaud along with dozens of other astronomy aficionados. What fun. Finally, it's your turn at the eyepiece. You peer in, and — there's the Veil Nebula as you've never seen it before. Late into the evening, you wander around this cosmic art gallery, viewing with awe the heavens' finest masterpieces.

All too soon, the convention is over. You leave with some tangible souvenirs — an eyepiece, perhaps, or the address of another astronomer who likes to observe double stars. But you also leave with renewed enthusiasm for astronomy. During that next night of solitude under the stars, you won't feel so alone.

Many gatherings are held in the United States and elsewhere each year. For a detailed wrapup, check the current issue of ASTRONOMY. Some of the largest are Stellafane (Springfield, Vermont, usually held in August), Riverside Telescope Makers Conference (Big Bear, California, Memorial Day weekend), Texas Star Party (Fort Davis, Texas, May), Astronomical Society of the Pacific (location varies, June), Astronomical League (location varies, July), Winter Star Party (Florida Keys, February), and Astrofest (Kankakee, Illinois, September).

## Astronomy Clubs

A given astronomy convention happens but once a year. Even if you attend several local gatherings annually, you'll encounter long stretches without that camaraderie that adds fun to any hobby. A good way to avoid becoming an astronomical hermit is to get involved in a local astronomy club. The activity schedule of a typical astronomy club includes regular monthly meetings and a smattering of seminars, field trips, and star parties. Many urban astronomy clubs have access to observing sites in the country, affording their members a light-free location to enjoy the night sky. Membership fees are quite reasonable, and often include a subscription to ASTRONOMY.

A well-organized astronomy club can offer many of the features that you get from a convention. The monthly meetings usually feature a guest speaker, and a club's annual slate of talks is planned to satisfy a wide variety of interests and levels. After the keynote talk, club members get together for informal chats. Search the following list for an astronomy club near you. You can attend the next monthly meeting and discuss the latest outer space happenings. Or you can sit at home telling your cat how much better M13 looks in your new 12-inch Dob. For information on astronomy clubs near you, check ASTRONOMY's Home Page on the Internet (http://www.kalmbach.com/astro/astronomy.html) or contact ASTRONOMY's editorial offices.

### Astronomy Organizations

If you have a particular interest in astronomy and want to link up with other amateurs knowledgeable in that field, look into the appropriate astronomy organization. Dozens of groups around the world cater to such topics as light pollution, lunar and planetary studies, variable star observing — the list goes on and on. Besides getting you in touch with amateur astronomers (and some professionals) who share your particular interests, a good astronomy organization will prove to be a valuable source of useful information. Start with ASTRONOMY's Home Page (http://www.kalmbach.com/astro/astronomy.html), which contains a list of organizations along with links to them.

### Astronomy on the Internet

Sometimes you feel like talking astronomy, and there isn't a convention or club meeting happening. Try the Internet. This space age method of communication and information dissemination has opened up the world to anyone who owns a PC and modem. Through most primary Internet servers you can dial into an astronomy club, where you can confer with other amateurs on a chat line or receive updated astronomy information on a message board. If you have access to the World Wide Web, you can access data from astronomy organizations anywhere in the world. Naturally, there is a fee, but it beats travel expenses. Check ASTRONOMY's Home Page (http://www.kalmbach.com/astro/astronomy.html) to begin your exploration of astronomy on the web.

### Playing the Neighborhood Ambassador

Each of us should be an ambassador to astronomy, sharing our love of the night sky with others. The best place to start is right in your neighborhood. You owe it to yourself to get them interested in the night sky. Befriend them. Talk with them. After all, these are the people who could put you out of business by installing garish outdoor lights on their property, obliterating your view.

Don't bore your neighbors by inviting them over to see that 13th-magnitude galaxy you finally glimpsed with your 6-inch Newtonian reflector. Instead, plan an informal neighborhood star party around a well-publicized astronomical event — Comet Hale-Bopp, perhaps.

Make things fun and interesting. Sneak in telescopic views of the Moon or a bright planet. Throw in a deep-sky wonder whose delicate beauty would be impossible to see if any stray light invaded your property. With a little luck, your neighbors will leave appreciating the night sky (and you) a little more. And who knows? Maybe you'll gain one or two new astronomy friends.

Want to be a "missionary of astronomy"? How about promoting an astronomy talk or a star party at a local library or public school? Again, concentrate on bright, easy to view showpieces. Hearing a gasp of awe as someone gazes at the moon for the first time will remind you of your first telescopic forays into the universe and rejuvenate your enthusiasm for those magic hours under the night sky. ☐

Andrew Peters

**The Omega Nebula**

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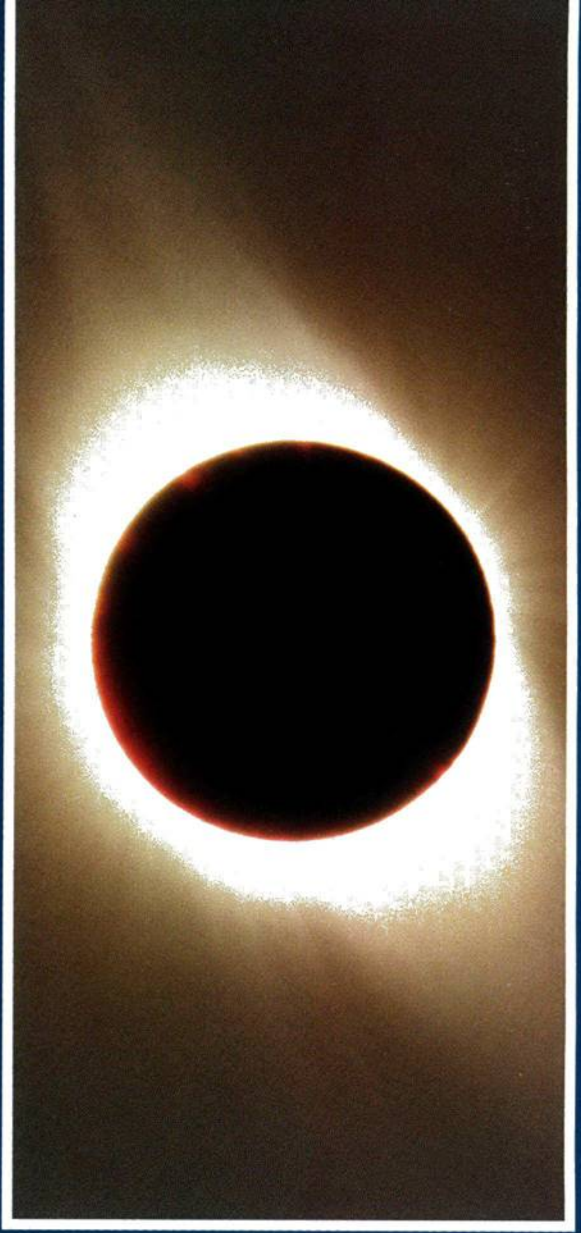

ASTRONOMY editors Dave Eicher and Rich Talcott invite you to daily talks and shipboard constellation watches. Then, on February 26, everyone will view the total solar eclipse through solar-safe filtered telescopes and binoculars. A trip you won't want to miss!

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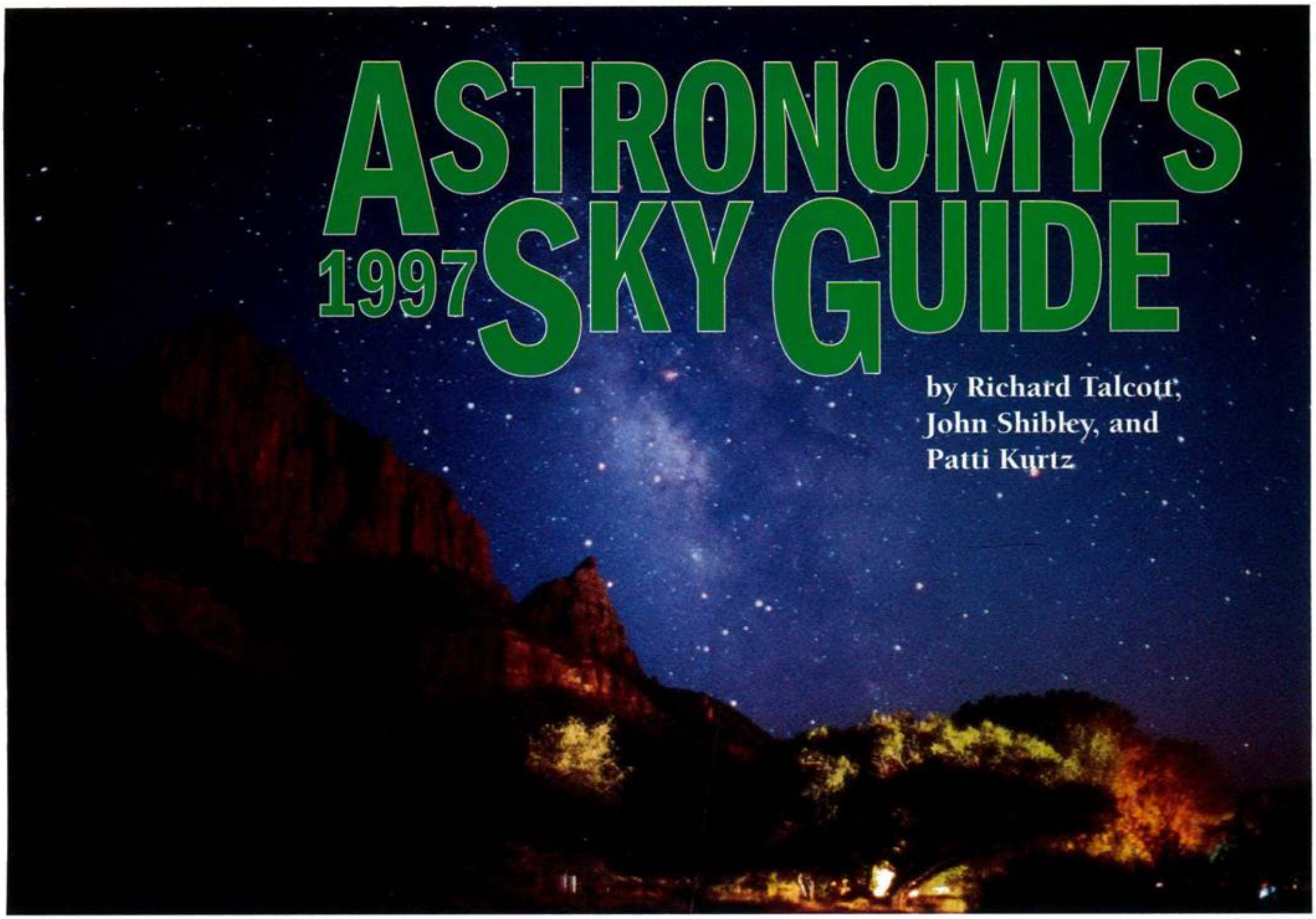
# ASTRONOMY'S 1997 SKY GUIDE

by Richard Talcott, John Shibley, and Patti Kurtz



Jerry Schad

## Eye on the Sky

You never know how charitable the universe is going to be when it comes to offering celestial events. Nearly every year features a lunar or solar eclipse of some kind. Close passages of bright asteroids, lunar-planetary conjunctions, and meteor showers, too, are annual events that can be counted on. Then there are those occurrences, like last year's near pass of Comet Hyakutake that transcend day-to-day astronomy.

Of course, any year in which an event of Hyakutake's caliber transpires would be extraordinary, but when it happens two years in a row, that's just mind-blowing. And yet that's s how 1997 is shaping up. This year, it's another over-the-top comet, Hale-Bopp, that illustrates celestial abundance and unpredictability.

Too near the Sun in January, the comet moves into the clear in early February, after which it rises in brilliance. Although it won't appear as large in the sky as Hyakutake, it will be considerably brighter: magnitude –1.7 is expected. This would make it the brightest comet in the past 20 years. A complete guide to Comet H-B can be found right after the monthly event calendars in this issue.

1997 is also going to be a prime year for planet watching. Mars, Jupiter, Saturn, and Uranus and Neptune all come to opposition. Mars' closest approach to Earth occurs March 20. Though not the best apparition, due to its southerly declination, this is your best chance to see the Red Planet close up for another two years.

Jupiter and Saturn are always fascinating when at opposition. Their apparent diameters are large, making it easier to look for atmospheric features and planet-satellite details in a small telescope. Be sure to check out Saturn's ever-widening rings.

Never very bright or large, Uranus and Neptune are at least well-placed for viewing at opposition. Through a small telescope, Uranus appears distinctly green and disk-like; Neptune a sort of aqua-blue dot. The opposition of these planets provides an excellent opportunity to push both your telescope and your observing skills to new limits.

Meteor aficionados will want to prepare for the Eta Aquarid meteor shower coming to a sky near you this spring. The Moon will be out of the way during its peak on May 6. Typical hourly rates are in the 20 to 30 range.

North America is treated to an almost-total lunar eclipse the night of March 23. Ninety-two percent of the Moon will slip into Earth's shadow, enough for refracted, reddened sunlight to endow the Moon with a slight blush.

These are the main events for 1997, but by no means the only ones. The sky this year holds many others, and they're all duly noted in the Sky Calendar on the following pages, complete with times, dates, observing tips, and other information indispensable to enjoying whatever the universe has to offer. — *Jeff Kanipe* ☐

## JANUARY

| S | M | T | W | T | F | S |
|---|---|---|---|---|---|---|
|  |  |  | ◑ | 2 | 3 | 4 |
| 5 | 6 | 7 | ● | 9 | 10 | 11 |
| 12 | 13 | 14 | ◐ | 16 | 17 | 18 |
| 19 | 20 | 21 | 22 | ○ | 24 | 25 |
| 26 | 27 | 28 | 29 | 30 | ◑ |  |

**Day Time (EST)**

1 **8 p.m.**
Mercury is in inferior conjunction

3 **Quadrantid meteor shower peaks**

7 **noon**
The Moon passes 5° north of Venus

12 **9 a.m.**
Mercury passes 3° north of Venus (morning)

13 **midnight**
**The Moon passes 2° north of Saturn**

17 **8 a.m.**
Neptune is in conjunction with the Sun

19 **1 a.m.**
The Moon passes 0.7° north of Aldebaran
**8 a.m.**
Jupiter is in conjunction with the Sun

23 **midnight**
**Mercury is at greatest western elongation (25°, morning)**

24 **9 a.m.**
Uranus is in conjunction with the Sun

28 **6 p.m.**
The Moon passes 3° south of Mars

Events in **bold** are ones you won't want to miss.
All times in the calendars are eastern time.
"Morning" or "evening" at the end of a listing denotes that the event appears before sunrise or after sunset, respectively.

# Moon and Saturn Make a Class Act

Winter sky watchers will appreciate a cosmic dance between the Moon and Saturn as the two draw together during the crisp night of January 13. These two dazzling performers begin the evening in the western sky nestled between Cetus and Pisces. As the night progresses and the pair sets, they glide to within 2° of each other.

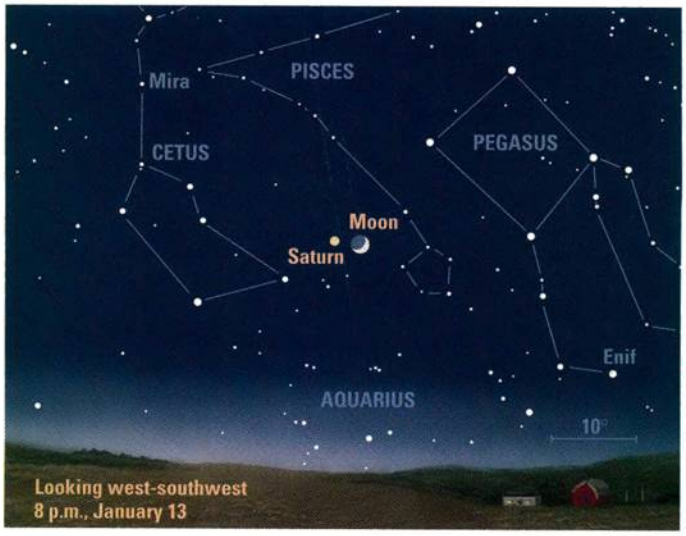
Such events are called conjunctions and occur when the Moon passes close to a planet or star in the sky. (Conjunctions can also happen between planets or between a planet and a star.) They are lovely sights to behold with the naked eye, but binoculars or a telescope at very low power can enhance the view.

Many features on January 13's five-day-old Moon should appear clear and sharp. This is a good time to get out a Moon map (see page 64) and explore Luna's rugged terrain. Spot Mare Crisium, the Sea of Crises, near the upper right-hand edge of the Moon. Early observers used to think that this and other similarly colored areas were bodies of water. We know now that these are ancient beds of once molten lava.

Golden-colored Saturn is much dimmer than the Moon, yet still an easy target at 1st magnitude. Binoculars hint at Saturn's rings and a telescope reveals them in all their glory, along with planetary detail and possibly some Saturnian moons. Look for 8th-magnitude Titan, the largest of Saturn's moons. This giant is the second largest of all moons in the solar system, larger, even, than the planet Mercury.

Saturn's rings tilt 4° to our line of sight and should show some detail, such as the Cassini division, in a 4-inch telescope. Before and after opposition, Saturn's shadow is cast onto the rings. Look for this shadow to the west of Saturn before opposition and to the east after opposition. For more information about Saturn's opposition this year, see the October section.

Being much farther away, Saturn is dimmer than our Moon. The Moon is 3,476 kilometers in diameter. Compare that to Saturn's diameter from ring-tip to ring-tip — about 273,200 km. If Saturn were at the distance of our Moon, it would appear nearly 80 times larger than the Moon.



Looking west-southwest
8 p.m., January 13

ASTRONOMY: Elisabeth Rowan

Bill Sterne, Jr.

### CONJUNCTIONS BETWEEN THE MOON AND PLANETS IN 1997

| Date | Planet | Time best seen |
|---|---|---|
| Jan. 13 | Saturn | evening |
| Mar. 23 | Mars | evening |
| Apr. 3 | Jupiter | morning |
| June 28 | Saturn | morning |
| July 6 | Venus | evening |
| July 11 | Mars | evening |
| Sept. 13 | Jupiter | evening |
| Nov. 3 | Mars | evening |
| Nov. 11 | Saturn | evening |
| Dec. 2 | Mars | evening |
| Dec. 8/9 | Saturn | evening |
| Dec. 31 | Mars | evening |

# Treat Your Valentine to Mars

On March 20, Mars makes its closest approach to Earth in 2½ years. By Valentine's Day, the Red Planet rises about 8:30 p.m., close to the heart of Virgo the Virgin. Details on the planet's surface should be easy to see in a small telescope.

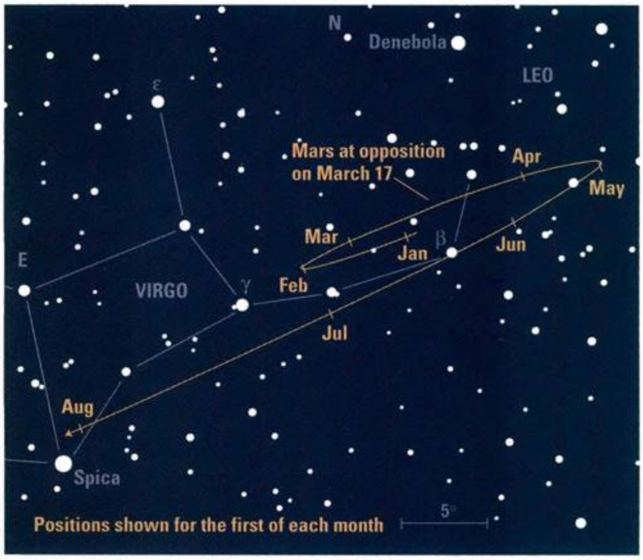
As Mars nears Earth, it appears to get larger and larger. By the time of its closest approach in mid-March (98.6 million kilometers from Earth), it will be 14.2" in diameter and will shine at magnitude –1.3. In mid-February, though, its apparent diameter is a respectable 12.0" and its magnitude is –0.6.

Start observing this fascinating planet early in the year. You will have a better chance of gleaning more detail in March if you become accustomed to observing it now.

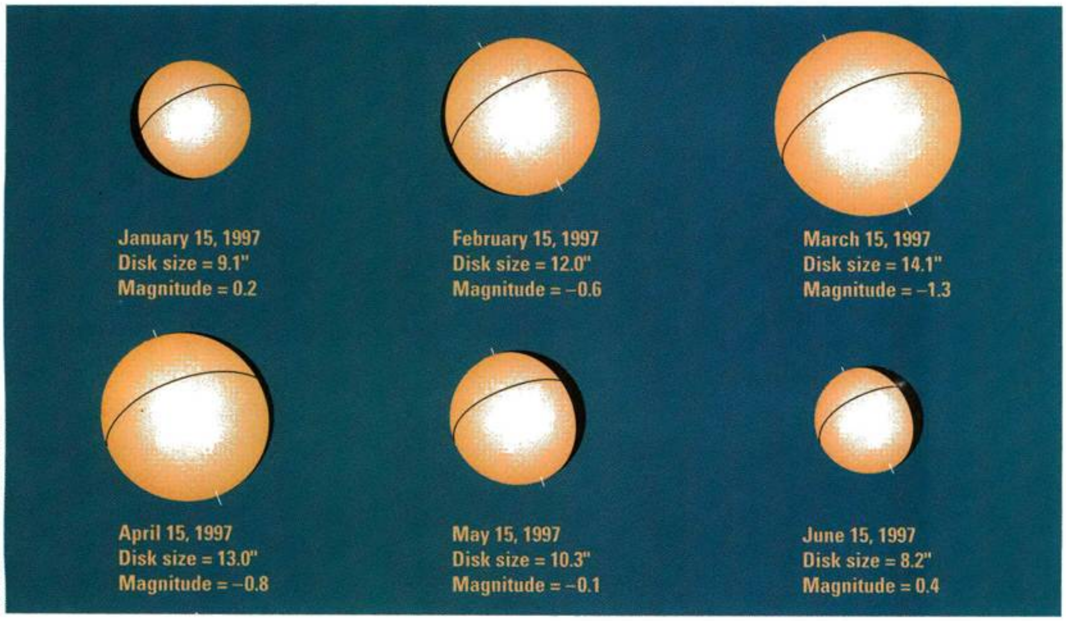
Look for the north and south polar caps — Mars' brightest surface features — and see if you can detect any changes in their size over the next couple of months. On the rest of the planet, look for dark surface markings. Sketch Mars every few days until opposition, then compare your drawings for changes in detail. Experienced Mars observers suggest using a Wratten #21 orange or #23A red filter to gain contrast.

Although we need to wait until 2003 for a truly great opposition, Mars puts on a good show over the coming months. It will be another two years before we are again treated to the Red Planet up close and personal, so don't wait.

Mark Haslam


N
Denebola
LEO
ε
Mars at opposition on March 17
Apr
May
Mar
Jan
β
Jun
E
VIRGO
γ
Feb
Jul
Aug
Spica
Positions shown for the first of each month
5°

ASTRONOMY: Elisabeth Rowan



January 15, 1997
Disk size = 9.1"
Magnitude = 0.2

February 15, 1997
Disk size = 12.0"
Magnitude = –0.6

March 15, 1997
Disk size = 14.1"
Magnitude = –1.3

April 15, 1997
Disk size = 13.0"
Magnitude = –0.8

May 15, 1997
Disk size = 10.3"
Magnitude = –0.1

June 15, 1997
Disk size = 8.2"
Magnitude = 0.4

ASTRONOMY: Elisabeth Rowan

## FEBRUARY

| S | M | T | W | T | F | S |
|---|---|---|---|---|---|---|
| | | | | | | 1 |
| 2 | 3 | 4 | 5 | 6 | ● | 8 |
| 9 | 10 | 11 | 12 | 13 | ◐ | 15 |
| 16 | 17 | 18 | 19 | 20 | 21 | ○ |
| 23 | 24 | 25 | 26 | 27 | 28 | |

**Day Time (EST)**

1 **6 a.m.**
Venus passes 1.0° south of Neptune (morning)

3 **1 a.m.**
Asteroid Vesta is in conjunction with the Sun

5 **7 p.m.**
**Venus passes 0.3° south of Jupiter (morning)**
**11 p.m.**
The Moon passes 5° north of Mercury

6 **3 a.m.**
The Moon passes 4° north of Neptune

7 **7 a.m.**
Venus passes 0.2° south of Uranus (morning)
**3 p.m.**
Mercury passes 1.4° south of Neptune (morning)

10 **noon**
**The Moon passes 1.8° north of Saturn**

12 **9 a.m.**
Mercury passes 1.0° south of Jupiter (morning)
**7 p.m.**
Mercury passes 0.9° south of Uranus (morning)

15 **6 a.m.**
The Moon passes 0.6° north of Aldebaran

16 **3 a.m.**
Jupiter passes 0.2° north of Uranus (morning)

24 **8 p.m.**
The Moon passes 3° south of Mars

## MARCH

| S | M | T | W | T | F | S |
|---|---|---|---|---|---|---|
| | | | | | | 1 |
| ◑ | 3 | 4 | 5 | 6 | 7 | ● |
| 9 | 10 | 11 | 12 | 13 | 14 | ◐ |
| 16 | 17 | 18 | 19 | 20 | 21 | 22 |
| ○ | 24 | 25 | 26 | 27 | 28 | 29 |
| 30 | ◑ | | | | | |

| Day | Time (EST) |
|---|---|
| 5 | **3 p.m.**<br>The Moon passes 4° north of Neptune |
| 6 | **4 a.m.**<br>The Moon passes 5° north of Uranus<br>**9 a.m.**<br>The Moon passes 5° north of Jupiter |
| 8 | **8 p.m.**<br>**Total solar eclipse (visible in Mongolia and Siberia)** |
| 10 | **4 a.m.**<br>The Moon passes 1.4° north of Saturn |
| 11 | **11 a.m.**<br>Mercury is in superior conjunction |
| 14 | **2 p.m.**<br>**The Moon passes 0.5° north of Aldebaran** |
| 17 | **3 a.m.**<br>**Mars is at opposition** |
| 20 | **9 a.m.**<br>Equinox (northern spring/southern autumn begins) |
| 23 | **9 a.m.**<br>**The Moon passes 4° south of Mars**<br>**midnight**<br>**Partial lunar eclipse** |
| 30 | **5 p.m.**<br>Saturn is in conjunction with the Sun |

# Take a Dip Into Earth's Shadow

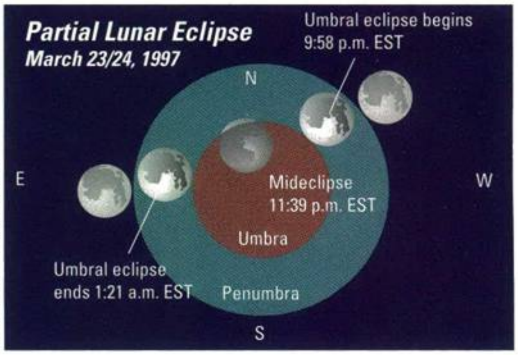
The rising Crow Moon of March spreads its light in the east about an hour before this year's most substantial eclipse for North America gets under way. Ages ago, an eclipse meant trouble to a superstitious populace. No longer considered a portent of doom for our technologically advanced society, a lunar eclipse can be one of the most satisfying spectacles the night sky has to offer.

On the evening of March 23, the Moon's bright light is steadily quenched as our lunar companion slides into Earth's shadow. Because 92 percent of the Moon will be covered at mideclipse, the plunge should be deep enough for a reddening of the shadowed portion of the disk. This reddening is caused by the Sun's light passing through Earth's atmosphere and bending back into the shadow. The light takes on a ruddy color because the shorter wavelength blue light is scattered out, leaving only the red.

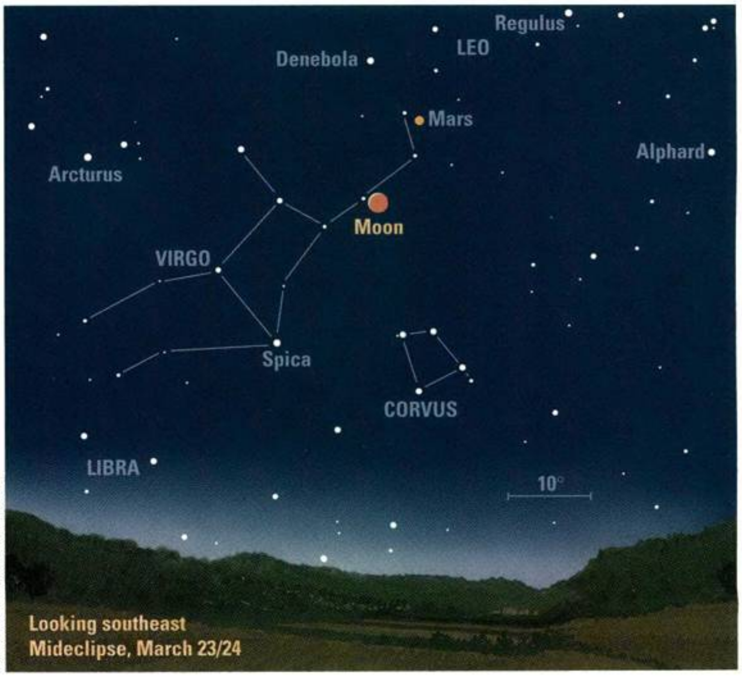
Fortunately for most North Americans, the sight will satisfy eclipse lovers coast to coast for over three hours. For western Europeans and Africans, however, the Moon sets while it is in eclipse. A dip into Earth's shadow is an extraordinary way to enjoy the night, whether you're relaxing in a lounge chair or observing with binoculars or a telescope.

An eclipse also offers a great opportunity to shake the dust off cameras and tripods. For detailed information about how to capture a lunar eclipse on film, see "Eclipse at Harvest Moon" by Alan Dyer, ASTRONOMY, September 1996.

Whatever you do, don't miss this marvelous event. This eclipse is the "best it gets" for observers in North America until January 21, 2000.

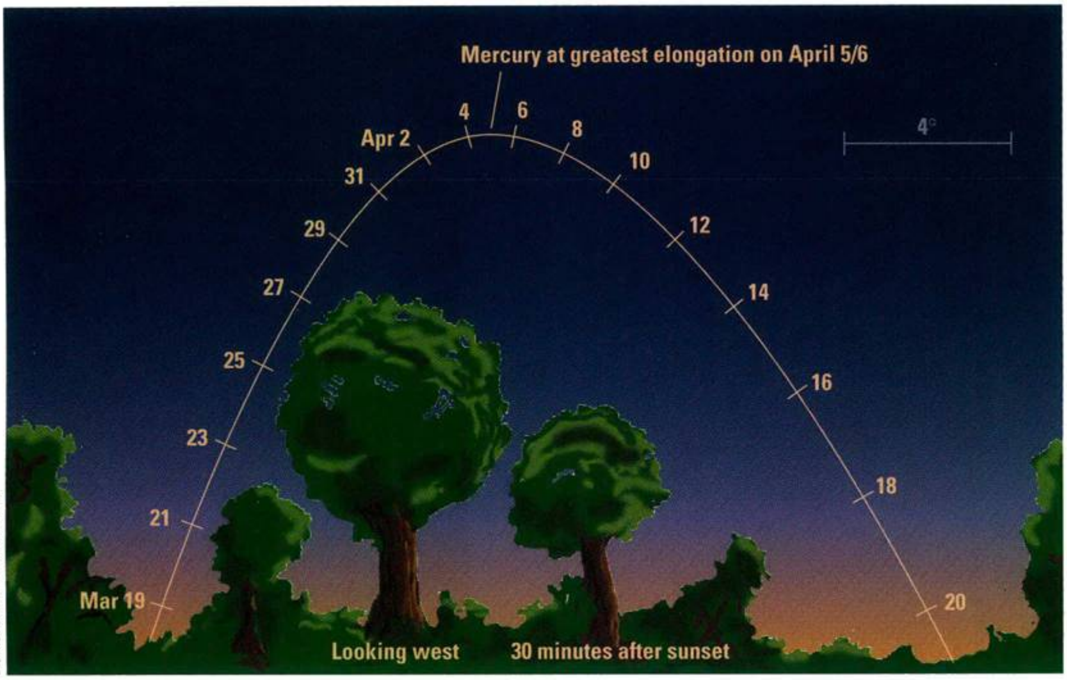

*Partial Lunar Eclipse*
*March 23/24, 1997*
Umbral eclipse begins 9:58 p.m. EST
N
E
W
S
Mideclipse 11:39 p.m. EST
Umbra
Umbral eclipse ends 1:21 a.m. EST
Penumbra
ASTRONOMY: Lee Vande Visse

Jim Manning



**Looking southeast**
**Mideclipse, March 23/24**
ASTRONOMY: Elisabeth Rowan

# A Mercury Double-Dare



ASTRONOMY: Phil Kirchmeier

Mercury gazers should be alert the evening of April 8. A one-day-old Moon lies about 7° south of the tiny planet in the twilight sky. Finding both objects in the west about 30 to 45 minutes after sunset makes for an interesting double challenge.

Mercury is the innermost planet and never strays far from the solar glare. It is a worthy target, however, during the first two weeks of April. For observers at mid-northern latitudes, this elusive planet appears highest in the evening sky this month.

You can add Mercury to your collection of night sky sights as long as you know just where to look. Mercury lurks low in the west after sunset as twilight fades to night, shining at magnitude –0.6 at the beginning of April and dropping to 0.8 by the 10th. It reaches its highest apparent altitude of 12° on April 5 and then falls back toward the Sun, disappearing from view around midmonth.

Using binoculars, scan just above a flat, unobstructed, western horizon about 30 to 45 minutes after sunset. Look for an orangish "star." For an added challenge, after you locate Mercury, try to spot it with your naked eye. A telescope will reveal Mercury's phase.

Don't give up — be persistent and become one of the members of the star-gazing community to reel-in this elusive wanderer.

George Livadaras

## WHEN TO SEE MERCURY IN 1997

### EVENING

| Greatest elongation | Visible from | Maximum altitude |
|---|---|---|
| April 5 (19°) | Mar. 21 to Apr. 17 | 12° |
| August 3 (27°) | July 3 to Aug. 25 | 7° |
| November 28 (22°) | Oct. 29 to Dec. 11 | 6° |

### MORNING

| Greatest elongation | Visible from | Maximum altitude |
|---|---|---|
| January 23 (25°) | Jan. 8 to Mar. 1 | 10° |
| May 22 (25°) | May 4 to June 18 | 5° |
| September 16 (18°) | Sept. 8 to Oct. 2 | 11° |

Maximum altitude is for an observer at 40° north latitude either 30 minutes after sunset or 30 minutes before sunrise.

## APRIL

| S | M | T | W | T | F | S |
|---|---|---|---|---|---|---|
|  |  | 1 | 2 | 3 | 4 | 5 |
| 6 | ● | 8 | 9 | 10 | 11 | 12 |
| 13 | ◐ | 15 | 16 | 17 | 18 | 19 |
| 20 | 21 | ○ | 23 | 24 | 25 | 26 |
| 27 | 28 | ◑ | 30 |  |  |  |

| Day | Time (EDT, after April 6) |
|---|---|
| 1 | **Comet Hale-Bopp is at perihelion**<br>**midnight**<br>The Moon passes 4° north of Neptune |
| 2 | **9 a.m.**<br>Venus is in superior conjunction<br>**2 p.m.**<br>The Moon passes 5° north of Uranus |
| 3 | **3 a.m.**<br>**The Moon passes 4° north of Jupiter** |
| 5 | **8 p.m.**<br>**Mercury is at greatest eastern elongation (19°, evening)** |
| 8 | **noon**<br>The Moon passes 6° south of Mercury |
| 10 | **midnight**<br>**The Moon passes 0.5° north of Aldebaran** |
| 19 | **2 a.m.**<br>The Moon passes 4° south of Mars |
| 21 | Lyrid meteor shower peaks |
| 25 | **7 a.m.**<br>Mercury is in inferior conjunction |
| 29 | **7 a.m.**<br>The Moon passes 4° north of Neptune<br>**11 p.m.**<br>The Moon passes 5° north of Uranus |
| 30 | **5 p.m.**<br>The Moon passes 4° north of Jupiter |

## MAY

| S | M | T | W | T | F | S |
|---|---|---|---|---|---|---|
| | | | | 1 | 2 | 3 |
| 4 | 5 | ● | 7 | 8 | 9 | 10 |
| 11 | 12 | 13 | ◐ | 15 | 16 | 17 |
| 18 | 19 | 20 | 21 | ○ | 23 | 24 |
| 25 | 26 | 27 | 28 | ◑ | 30 | 31 |

**Day Time (EDT)**

**4** **noon**
The Moon passes 0.8° north of Saturn
**Eta Aquarid meteor shower peaks**

**5** **noon**
The Moon passes 1.2° south of Mercury

**8** **10 a.m.**
The Moon passes 0.6° north of Aldebaran

**16** **noon**
The Moon passes 2° south of Mars

**19** **4 a.m.**
Venus passes 6° north of Aldebaran (evening)

**22** **7 p.m.**
Mercury is at greatest western elongation (25°, morning)

**25** **6 a.m.**
**Pluto is at opposition**

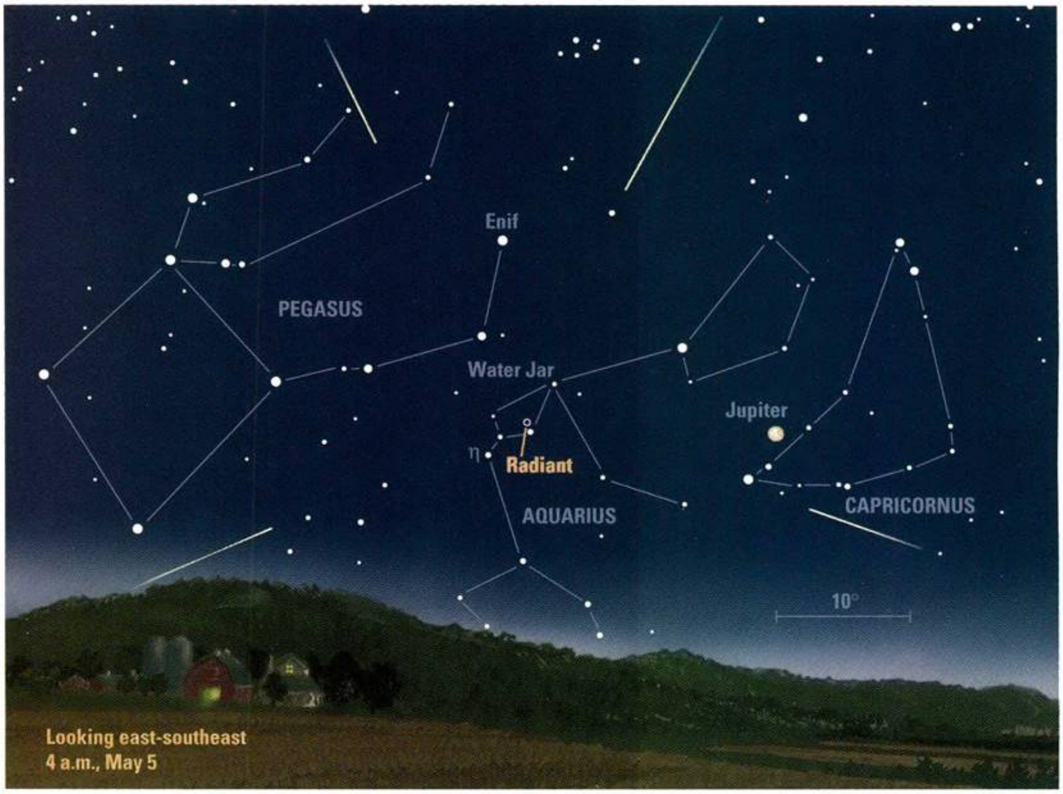
**26** **noon**
The Moon passes 4° north of Neptune

**27** **4 a.m.**
The Moon passes 4° north of Uranus

**28** **2 a.m.**
**The Moon passes 4° north of Jupiter**

**31** **11 p.m.**
The Moon passes 0.5° north of Saturn

# May Showers up a Storm of Meteors



ASTRONOMY: Elisabeth Rowan

### METEOR SHOWERS FOR 1997

| Name | Peak date | Moon's phase | Prospects |
|---|---|---|---|
| Quadrantids | Jan. 3 | Waning crescent | Fair |
| Lyrids | Apr. 21 | Full | Poor |
| Eta Aquarids | May 4 | New | Excellent |
| Delta Aquarids | July 28 | Waning crescent | Fair |
| Perseids | Aug. 12 | Waxing gibbous | Good |
| Orionids | Oct. 21 | Waning gibbous | Poor |
| Leonids | Nov. 17 | Waning gibbous | Poor |
| Geminids | Dec. 13 | Full | Poor |

M.L. Clark

Get up early in the morning, particularly at the beginning of the month, and watch the "Water Jar" asterism in Aquarius pour forth its meteors. At mid-northern latitudes, the "watery" radiant rises an hour or two before morning twilight begins. As with most meteor showers, the best time to view is after midnight. That's because Earth is then charging head-on through the meteor cloud, creating the largest number of meteors after that time.

Meteors are not really falling or shooting stars, of course. "They are less shooting stars than falling fluff," astronomer Carl Sagan once said.

Meteors are the debris left in the wake of a passing comet. When Earth crosses that wake during its own orbit, some of the particles fall into the atmosphere and vaporize, causing brief and sometimes bright streaks of light during their entry. These particles are rarely larger than a grain of sand.

The Eta Aquarids are associated with Halley's Comet. They are very bright, fast, and often leave persistent trains.

If you're interested in photographing these splashy visitors, see "Catch a Perseid on Film," ASTRONOMY, August 1996. However you choose to observe them, meteor showers provide a great excuse to stretch out in a lawn chair and enjoy the night sky.Nothing could be more relaxing.

# Journey the June Milky Way

Ray Grover

By midevening it treads a ghostly path high in the east. Native American cultures considered it a pathway for souls. Who could blame them for making such an assumption? The summer Milky Way does indeed take on an ethereal nature under rural skies, far away from the ravages of light pollution. Many a city dweller has stood awestruck at their first sight of our home galaxy. Have you ever been one of them?

If not, journey away from the metro glow for a view into the Milky Way. Start tracing it from the northeast, near house-shaped Cepheus the King and cross-shaped Cygnus the Swan. This is where our Galaxy's cloudy sheen begins in earnest. Take a look through binoculars; what looks cloudy to the eye is actually millions upon millions of stars, fellow denizens of a spiral galaxy we call home, one of billions of such galaxies in the universe.

As you progress into the Swan, note how the Milky Way's glow gets decidedly brighter and fatter. This marks a direct line of sight down the very spiral arm in which our Sun resides. Moving south into Aquila and Ophiuchus, the Galaxy's soft glow splits into diverging branches, cleaved by a rift. This dark rift consists of nonglowing gas and dust that resides in the galactic plane. Isolated, inky globs lie up and down the Milky Way's length, visible to the naked eye or in low-power field glasses.

Continuing south into Scutum and Sagittarius, we come across many clouds of glowing gas and stars. Here we are looking toward the Galaxy's center and into a neighboring spiral arm's complexity. Even simple binoculars reveal sparkling clusters of newborn stars, as well as patches of fluorescent gas clouds spawning still more suns, some bigger, some smaller than our home star.

Now that you've cased out this sight with the unaided eye and binoculars, grab a star atlas and move on to a telescope. A bevy of deep-sky objects lies sprinkled throughout the summer sky to make for a lifetime's worth of observing. Make the summer of '97 a time to begin your galactic journey.

## JUNE

| S | M | T | W | T | F | S |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | ● | 6 | 7 |
| 8 | 9 | 10 | 11 | 12 | ◐ | 14 |
| 15 | 16 | 17 | 18 | 19 | ○ | 21 |
| 22 | 23 | 24 | 25 | 26 | ◑ | 28 |
| 29 | 30 | | | | | |

**Day Time (EDT)**

**3 9 a.m.**
The Moon passes 1.6° south of Mercury

**6 1 p.m.**
The Moon passes 6° south of Venus

**13 noon**
**The Moon passes 0.3° south of Mars**

**14 10 a.m.**
Mercury passes 5° north of Aldebaran (morning)

**21 4 a.m.**
Solstice (northern summer/southern winter begins)

**22 6 p.m.**
The Moon passes 4° north of Neptune

**23 9 a.m.**
The Moon passes 4° north of Uranus
**7 p.m.**
Venus passes 5° south of Pollux (evening)

**24 8 a.m.**
The Moon passes 4° north of Jupiter

**25 3 p.m.**
Mercury is in superior conjunction

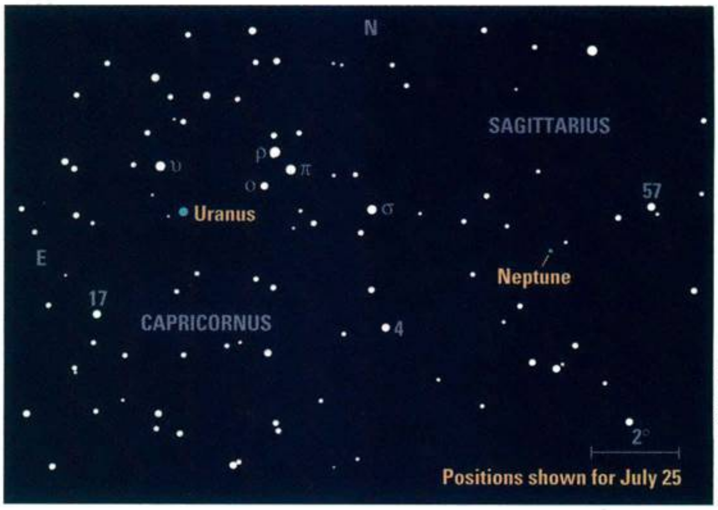
**28 8 a.m.**
**The Moon passes 0.2° north of Saturn**

## JULY

| S | M | T | W | T | F | S |
|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | ● | 5 |
| 6 | 7 | 8 | 9 | 10 | 11 | ◐ |
| 13 | 14 | 15 | 16 | 17 | 18 | ○ |
| 20 | 21 | 22 | 23 | 24 | 25 | ◑ |
| 27 | 28 | 29 | 30 | 31 | | |

| Day | Time (EDT) |
|---|---|
| 2 | 1 a.m.<br>The Moon passes 0.6° north of Aldebaran |
| 4 | midnight<br>Mercury passes 5° south of Pollux (evening) |
| 6 | 10 p.m.<br>**The Moon passes 5° south of Venus** |
| 11 | 9 p.m.<br>**The Moon passes 1.8° north of Mars** |
| 19 | 6 a.m.<br>Asteroid Pallas is at opposition |
| 21 | 3 a.m.<br>**Neptune is at opposition**<br>1 p.m.<br>The Moon passes 4° north of Jupiter |
| 22 | 9 p.m.<br>**Venus passes 1.2° north of Regulus (evening)** |
| 24 | noon<br>Asteroid Juno is in conjunction with the Sun |
| 25 | 3 p.m.<br>The Moon passes 0.02° south of Saturn |
| 26 | 8 p.m.<br>Mercury passes 0.5° south of Regulus (evening) |
| 28 | **Southern Delta Aquarid meteor shower peaks** |
| 29 | 7 a.m.<br>**The Moon passes 0.4° north of Aldebaran**<br>3 p.m.<br>**Uranus is at opposition** |

# Uranus and Neptune at Opposition



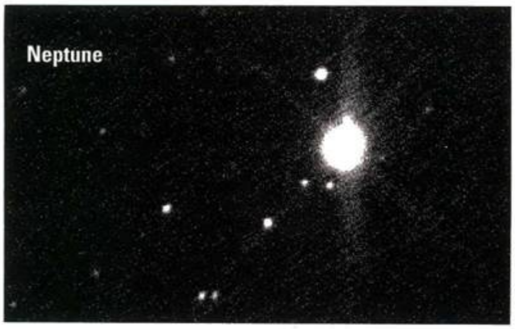
Positions shown for July 25

ASTRONOMY: Rick Johnson

Opposition is the optimum time to observe a planet. During any given apparition, this is the time when the planet is closet to Earth and can be seen throughout the night. Opposition occurs when a planet lies opposite the Sun as seen from Earth.

This month sees two planets, Uranus and Neptune, at opposition from the Sun, which is a great excuse to go out and get a look at two of the gas giants in our solar system.

At opposition, Uranus is visible to the naked eye at magnitude 5.7, and is not a difficult target with binoculars. We see this celestial wanderer with relative ease nowadays because we know where to look, but it wasn't always so simple.



Bob Hatfield

Greg Terrance

Uranus was discovered in March 1781 by William Herschel, who at first mistook it for a comet. This amateur astronomer and telescope maker carefully logged his sightings until the "comet" was shown to be traveling in a nearly circular orbit that defined it as a planet. William Herschel was knighted by King George III as the discoverer of a new world, and Uranus was named for the god of heaven.

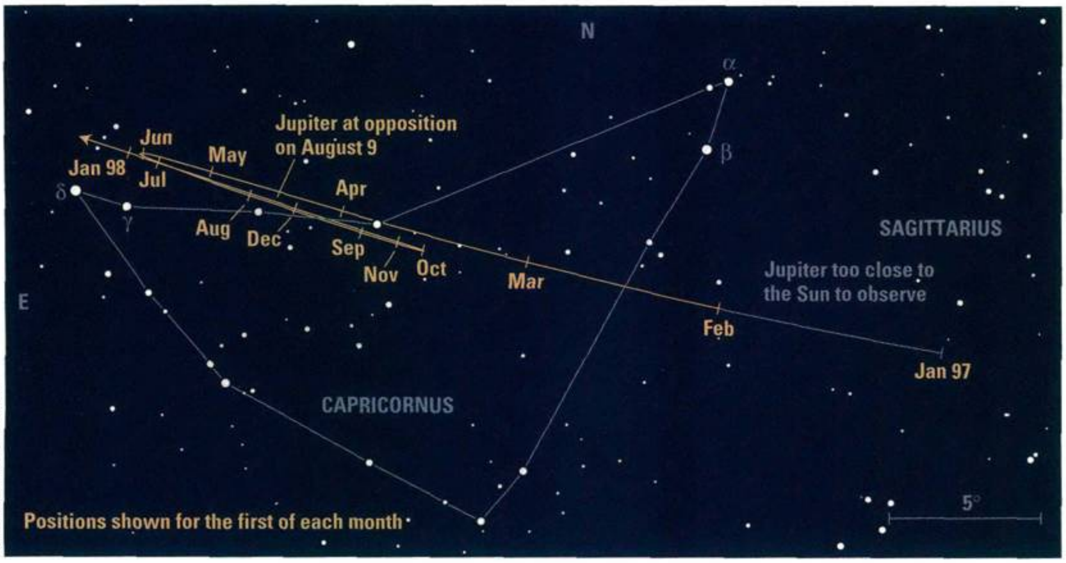
Since then, we've had a much closer look at this beautiful blue-green planet. The Voyager 2 spacecraft flew past in August 1989 and discovered ten additional moons to the five known. It also imaged ten thin rings.

After Uranus' discovery, astronomers were puzzled by its erratic behavior. Rarely was it precisely where it was supposed to be according to their calculations. They theorized that another celestial body must be responsible. About 60 years later, after a series of errors and coincidences (see "Neptune's Discovery 150 Years Later," ASTRONOMY, October 1996), Neptune was brought into the solar system fold by Urbain Jean Joseph Le Verrier, who calculated a remarkably accurate position, and observer Johann Galle.

Neptune lies more than a billion kilometers farther from the Sun than Uranus and is roughly the same size. It has eight moons, one of which takes nearly a year to revolve around the planet. Its relatively short day is only about 17 hours long, but one lap around the Sun at Neptune's distance takes about 165 of our years. Currently it is the farthest planet from the Sun and will remain so until February 1999, when Pluto will once again take up its usual place as the farthest-flying planet in the solar system.

Finding this blue-gray giant against the background stars of eastern Sagittarius is something of a challenge. It is visible in binoculars as an 8th-magnitude "star" and is fairly easy to locate if you use a reliable star chart. The diagram above shows stars down to magnitude 8.5, so you shouldn't have much problem telling it apart from the stars. If you're using a telescope, can you resolve a disk or discern its color? Go out and enjoy the search for Neptune which, until Pluto's discovery eighty years later, was thought to be the final frontier in our solar system.

# Mighty Jove of the Summer Night


N
α
β
Jun
May
Jupiter at opposition on August 9
Jan 98
δ
Jul
γ
Apr
Aug
Dec
Sep
Nov
Oct
Mar
SAGITTARIUS
Jupiter too close to the Sun to observe
E
Feb
Jan 97
CAPRICORNUS
5°
Positions shown for the first of each month

ASTRONOMY: Rick Johnson

That bright, white star in the southeast after sunset this month *isn't*. It's our solar system's largest planet, Jupiter. Mighty Jove lies at opposition on August 9, a moment when Earth is directly between it and the Sun. This means Jupiter rises at sunset, passes due south at local midnight, and sets in the southwest by daybreak. Opposition also marks the beginning of Jupiter's observing season, when the behemoth (11 Earths could span Jupiter's equator) graces evening skies.

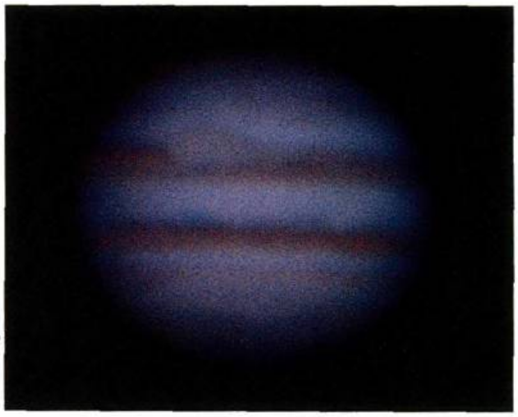
A quick glance through even the simplest binoculars reveals something stunning about Jupiter: four planet-sized moons that change position from night to night as they orbit their home world. These companions, called the Galilean satellites, for it was Galileo who first spotted them in 1610, are really worlds unto themselves. Each is roughly our Moon's size, with Ganymede measuring slightly bigger than Mercury.

Innermost Io is one of the solar system's most intriguing objects. Its surface completely renews itself every year, thanks to a network of volcanos that spew streams of molten sulfur. Some of this sulfur drizzles into Io's orbit around Jupiter to form a torus along the moon's path.

The other satellites are no less fascinating: Europa's icy surface masks a globe-girdling ocean that could conceivably harbor life forms not unlike those found near Earth's deep-sea vents. Callisto and Ganymede's ancient surfaces are pockmarked by craters and crisscrossed by fissures similar to pressure ridges on a frozen lake.

Enigmatic moons aside, Jupiter's atmosphere is just as remarkable. The view through a telescope reveals dark belts of sinking air, where we see deep into Jupiter's cloudtops, and lighter zones of rising air. Bluish festoons drape themselves in and around the planet's equatorial zone. But most intriguing is Jupiter's Great Red Spot, a gigantic storm that's lingered for many centuries. Earth would easily fit within its boundaries.

Such is the richness of Jupiter. Many astronomy enthusiasts spend countless hours drawing and photographing its myriad detail. August is truly the month for Jupiter-lovers.



Jim Baumgardt

## GALILEO SPACECRAFT FLYBYS IN 1997

| Date | Satellite | Closest approach (km) |
|---|---|---|
| February 20 | Europa | 588 |
| April 5 | Ganymede | 3,065 |
| May 7 | Ganymede | 1,584 |
| June 25 | Callisto | 416 |
| September 17 | Callisto | 524 |
| November 6 | Europa | 1,119 |

## AUGUST

| S | M | T | W | T | F | S |
|---|---|---|---|---|---|---|
| | | | | | 1 | 2 |
| ● | 4 | 5 | 6 | 7 | 8 | 9 |
| 10 | ◐ | 12 | 13 | 14 | 15 | 16 |
| 17 | ○ | 19 | 20 | 21 | 22 | 23 |
| ◑ | 25 | 26 | 27 | 28 | 29 | 30 |
| 31 | | | | | | |

| Day | Time (EDT) |
|---|---|
| 2 | **7 p.m.**<br>**Mars passes 1.7° north of Spica (evening)** |
| 3 | **8 p.m.**<br>Mercury is at greatest eastern elongation (27°, evening) |
| 5 | **3 p.m.**<br>The Moon passes 1.0° north of Mercury |
| 6 | **5 a.m.**<br>The Moon passes 1.6° south of Venus |
| 9 | **10 a.m.**<br>**Jupiter is at opposition**<br>**11 a.m.**<br>The Moon passes 4° north of Mars |
| 12 | **Perseid meteor shower peaks** |
| 16 | **noon**<br>The Moon passes 4° north of Neptune |
| 17 | **6 p.m.**<br>The Moon passes 4° north of Jupiter |
| 21 | **10 p.m.**<br>**The Moon passes 0.008° south of Saturn** |
| 25 | **1 p.m.**<br>The Moon passes 0.3° north of Aldebaran |
| 29 | **11 p.m.**<br>**Asteroid Ceres is at opposition** |
| 31 | **10 a.m.**<br>Mercury is in inferior conjunction |

## SEPTEMBER

| S | M | T | W | T | F | S |
|---|---|---|---|---|---|---|
| ● | 2 | 3 | 4 | 5 | 6 | |
| 7 | 8 | ◐ | 10 | 11 | 12 | 13 |
| 14 | 15 | ○ | 17 | 18 | 19 | 20 |
| 21 | 22 | ◑ | 24 | 25 | 26 | 27 |
| 28 | 29 | 30 | | | | |

**Day Time (EDT)**

**1** **8 p.m.**
Partial solar eclipse

**5** **8 a.m.**
The Moon passes 3° north of Venus

**6** **1 a.m.**
**Venus passes 1.9° north of Spica (evening)**

**7** **5 a.m.**
The Moon passes 5° north of Mars

**12** **9 p.m.**
The Moon passes 4° north of Neptune

**13** **10 a.m.**
The Moon passes 4° north of Uranus
**midnight**
**The Moon passes 4° north of Jupiter**

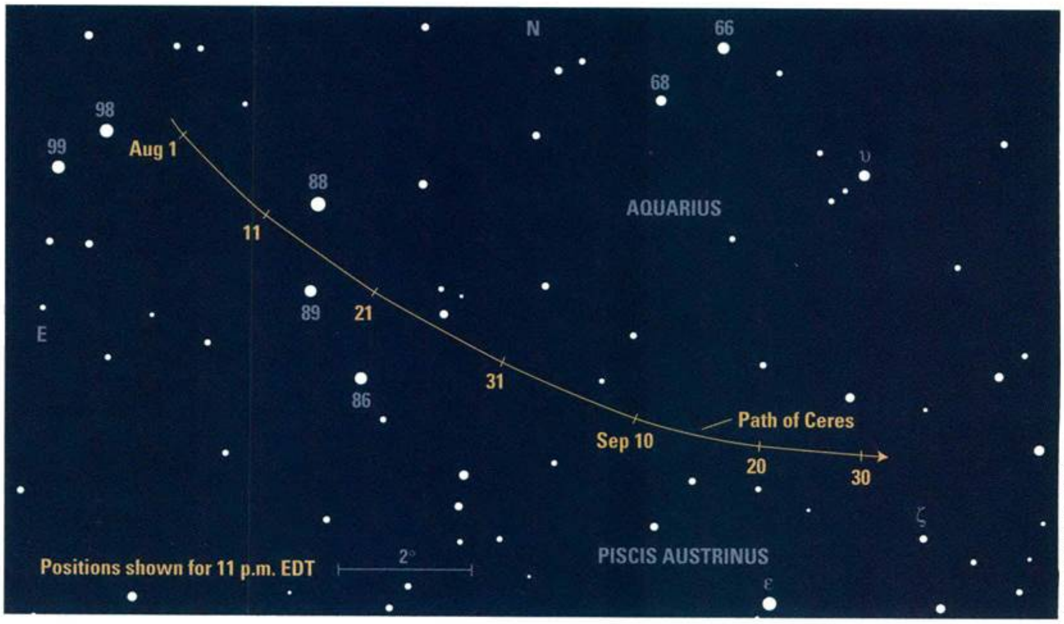
**16** **3 p.m.**
**Total lunar eclipse (visible in the Eastern Hemisphere)**
**6 p.m.**
**Mercury is at greatest western elongation (18°, morning)**

**18** **6 a.m.**
The Moon passes 0.2° north of Saturn

**21** **8 p.m.**
The Moon passes 0.3° north of Aldebaran

**22** **8 p.m.**
Equinox (northern autumn/southern spring begins)

# A Planetesimal for Autumn



ASTRONOMY: Elisabeth Rowan

Our solar system crawls with them; one will even hit Earth some day, as the dinosaurs tragically found out 65 million years ago. These teeming hordes are the asteroids, flotsam of shattered planets or the remains of ones thwarted in formation. There are thousands, perhaps millions, of these tiny bodies. During September the first one ever found, Ceres (discovered on January 1, 1801), is an easy target for backyard observers equipped with telescopes.

1 Ceres (asteroids are numbered in order of discovery) lies in a part of the solar system where there ought to be a planet, so thought 18th-century astronomers. The huge gap between Mars and Jupiter begged for a hidden planet. So off to the scopes European astronomers went, determined to find Planet X. Instead they stumbled upon diminutive Ceres, far too underwhelming to be a planet worthy of pursuit. Yet there it was, followed in short order by the discoveries of Pallas, Juno, and Vesta. Soon many other asteroids were turning up in a zone, or belt, around the Sun where Planet X should have been.

What was going on?

It turns out that a gravitational tug-of-war between Jupiter, our solar system's largest planet, and the Sun, kept a large planet from forming in the first place. No sooner would a sizable planetoid start to coalesce then another piece of rock would come along to shatter it. More likely, some rock chunks never got a chance to form even a modestly large body.

Over time, orbital resonances between Jupiter and the other planets scattered some asteroids into different parts of the solar system. Some of them, the so-called Near Earth Objects, pose a threat to Earth. Early next year, a NASA spacecraft dubbed NEAR (for Near Earth Asteroid Rendezvous) will survey one called Eros up close for the first time. In June 1997, NEAR flies past a main-belt asteroid.

For present-day, Earthbound observers, however, the thrill of asteroid observing comes from following their nightly motions and comprehending their pedigree. 1 Ceres offers such an opportunity this fall. Still others are visible throughout the year; see the table here and consult ASTRONOMY's Sky Almanac section for monthly updates.

## ASTEROIDS IN 1997

| Name | Opposition date | Magnitude | Constellation |
|---|---|---|---|
| 7 Iris | April 13 | 9.4 | Virgo |
| 29 Amphitrite | April 16 | 9.4 | Virgo |
| 15 Eunomia | June 17 | 9.2 | Scorpius |
| 19 Fortuna | August 24 | 9.4 | Aquarius |
| 1 Ceres | August 29 | 7.7 | Aquarius |
| 8 Flora | September 27 | 8.1 | Cetus |
| 4 Vesta | October 17 | 6.4 | Cetus |
| 9 Metis | November 16 | 8.3 | Taurus |
| 23 Thalia | December 9 | 9.2 | Taurus |
| 27 Euterpe | December 19 | 8.4 | Taurus |

# Saturnshine All Evening

Jack Newton

The gas giant planets of our Sun's family have all come to opposition over the past few months: Uranus and Neptune in July, followed by Jupiter in August. Now it's Saturn's turn, coming into an arrangement with Earth where our planet lies between it and the Sun. For us, this means the Ringed Planet is in the sky all night, rising at sunset and setting at sunrise.

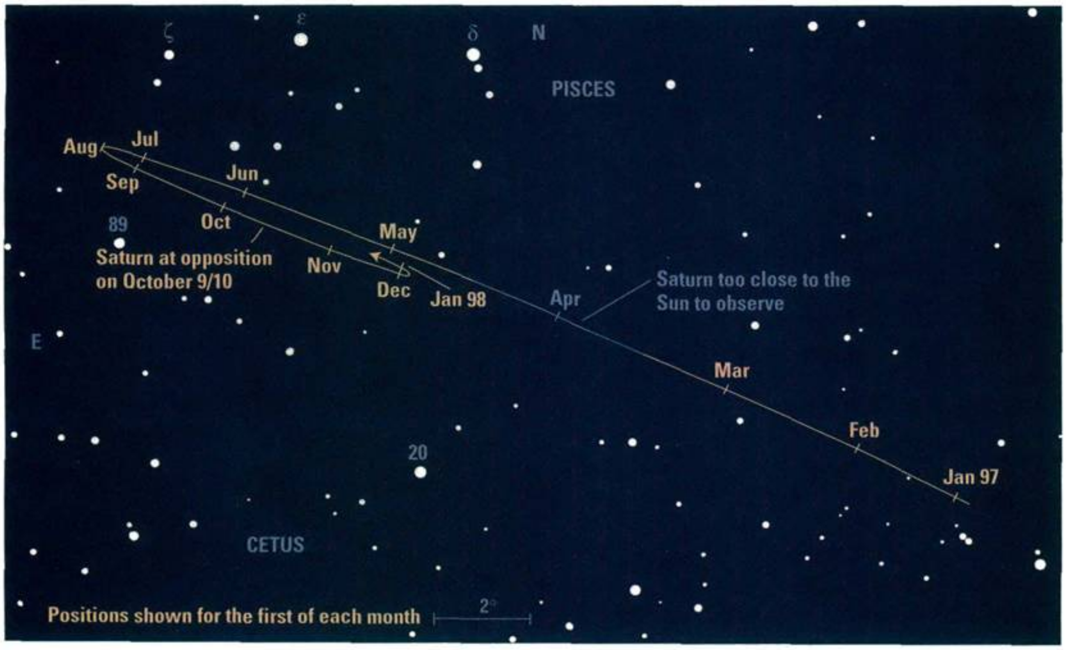
Aside from its resplendent ring system, Saturn's just another gas giant planet. Gas giants, as the name suggests, are gaseous and gargantuan, especially when compared with the inner solar system's smaller, rocky planets. A rocky core slightly larger than Earth probably lurks at the core of every gas giant, but 99-plus percent of each planet's bulk lies in the form of gases like hydrogen and helium.

And the gas doesn't just sit there.

Gas giants are huge weather machines powered for the most part by energy left over from the very process of planetary formation. Heat wells up from deep inside each planet, spawning huge storms and driving winds of more than 600 mph. Through a telescope, Jupiter hints at this violence with alternating cloud belts and zones. Saturn's cloud bands are subtler; Uranus and Neptune are too distant to see anything through a telescope.

Whatever commonalities Saturn shares with its cousins ends with rings. To be sure, Jupiter, Uranus, and Neptune do have ring systems, but Saturn's are the only ones visible in backyard telescopes. Three distinct rings extend some 76,600 kilometers from Saturn's cloudtops, each only a few hundred meters thick. The rings in turn are composed of thousands of ringlets that contain ice and rock ranging from house-sized chunks right down to microscopic particles.

All this complexity is due to come under scrutiny when NASA launches a mission this month to gather pictures and info on Saturn's atmosphere, rings, and moons. One moon in particular, smog-enshrouded Titan, gets an atmospheric drop-probe, similar to Jupiter's Galileo. Look for results in 2004.


ζ
ε
δ
N
PISCES
Aug
Jul
Sep
Jun
89
Oct
May
Saturn at opposition on October 9/10
Nov
Dec
Jan 98
Apr
Saturn too close to the Sun to observe
E
Mar
Feb
20
Jan 97
CETUS
2°
Positions shown for the first of each month

ASTRONOMY: Elisabeth Rowan

## OCTOBER

| S | M | T | W | T | F | S |
|---|---|---|---|---|---|---|
| | | | ● | 2 | 3 | 4 |
| 5 | 6 | 7 | 8 | ◐ | 10 | 11 |
| 12 | 13 | 14 | ○ | 16 | 17 | 18 |
| 19 | 20 | 21 | 22 | ◑ | 24 | 25 |
| 26 | 27 | 28 | 29 | 30 | ● | |

| Day | Time (EDT, before October 26) | |
|---|---|---|
| 5 | 9 a.m. | The Moon passes 7° north of Venus |
| 6 | 2 a.m. | The Moon passes 6° north of Mars |
| 9 | midnight | **Saturn is at opposition** |
| 10 | 5 a.m. | The Moon passes 4° north of Neptune |
| | 6 p.m. | The Moon passes 4° north of Uranus |
| 11 | 7 a.m. | The Moon passes 4° north of Jupiter |
| | 6 p.m. | **Mars passes 3° north of Antares (evening)** |
| 13 | 5 p.m. | Mercury is in superior conjunction |
| 15 | 2 p.m. | The Moon passes 0.4° north of Saturn |
| 16 | 6 p.m. | **Venus passes 1.7° north of Antares (evening)** |
| 17 | 1 a.m. | **Asteroid Vesta is at opposition** |
| 19 | 5 a.m. | **The Moon passes 0.3° north of Aldebaran** |
| 21 | | Orionid meteor shower peaks |
| 26 | 6 p.m. | **Venus passes 2° south of Mars (evening)** |

## NOVEMBER

| S | M | T | W | T | F | S |
|---|---|---|---|---|---|---|
|  |  |  |  |  |  | 1 |
| 2 | 3 | 4 | 5 | 6 | ◐ | 8 |
| 9 | 10 | 11 | 12 | 13 | ○ | 15 |
| 16 | 17 | 18 | 19 | 20 | ◑ | 22 |
| 23 | 24 | 25 | 26 | 27 | 28 | ● |
| 30 |  |  |  |  |  |  |

**Day Time (EST)**

3 **midnight**
**The Moon passes 6° north of Mars**

4 **6 a.m.**
The Moon passes 9° north of Venus

6 **2 a.m.**
**Venus is at greatest eastern elongation (47°, evening)**
**10 a.m.**
The Moon passes 4° north of Neptune
**midnight**
The Moon passes 4° north of Uranus

7 **3 p.m.**
The Moon passes 4° north of Jupiter

11 **8 p.m.**
**The Moon passes 0.4° north of Saturn**

13 **11 p.m.**
Mercury passes 2° north of Antares (evening)

15 **3 p.m.**
The Moon passes 0.5° north of Aldebaran

17 Leonid meteor shower peaks

27 **noon**
Pluto is in conjunction with the Sun

28 **11 a.m.**
Mercury is at greatest eastern elongation (22°, evening)

# Venus Invades America's Heartland

People who seldom pay a passing glance at the sky are about to be visited by a UFO during November. At first it may seem like a trick of the eye, but soon the bright, multicolored light will zip along a tree line, moving as fast as any panicked but competent driver can drive. Overhead it'll swoop, perhaps to land beyond a ridge, out of sight as the car engine revs and a hastily executed maneuver banks car and passengers off in an opposite direction, say, towards Pegasus rising in the northeast.

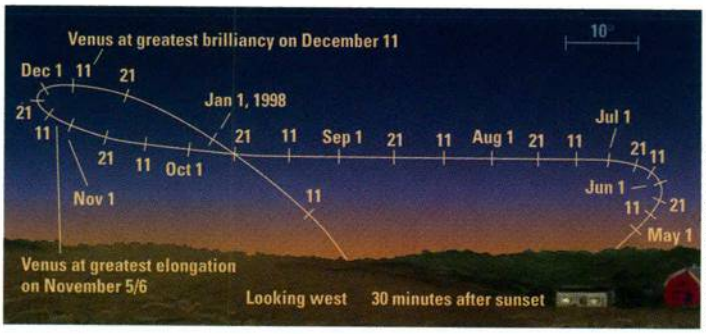
A close encounter of the first kind? Hardly. It's just our whimsical sister world, Venus, hovering low in the southwest after sunset, carrying on the grand tradition of being confused for a vanguard of alien specimen collectors.

Dazzling Venus (bright, white Venusian clouds reflect 65% of the sunlight that strikes them) blazes throughout November and into December like a Roman Candle. It's been an evening star since May, but this month the planet is especially bright. And colorful. Light from its disk passes through hundreds of kilometers of churning atmosphere, getting bent and twisted into myriad colors.

And because the planet's light is so bright to begin with, the muted brilliance only adds more to the show. A low Venus often doubles the number of UFO reports to police. Airline pilots often give Venus a wide berth, ostensibly to avoid another aircraft. Fighter pilots have been known to empty ammunition magazines and even launch air-to-air missiles at the perceived intruder.

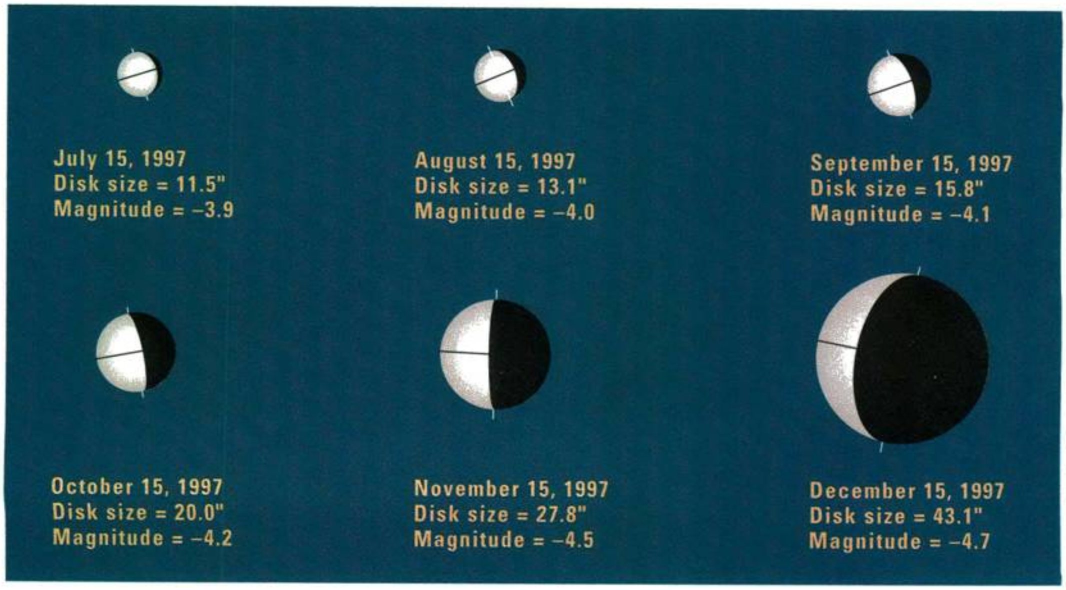
But you, the informed skywatcher, now know better. Look quickly this month, for as Thanksgiving gives way to the Advent season, sparkling Venus gets lower and lower until it sinks below the horizon, to reappear as a morning "star" during 1998.

Venus, and Mercury too for that matter, alternates between morning and evening appearances because it orbits between the Sun and Earth. Only a planet beyond the orbit of our world, so-called "superior" planets, have opportunities to remain up all night. The inferior planets are perennial attendants to solar twilight.


Venus at greatest brilliancy on December 11
10°
Dec 1
11
21
21
11
Jan 1, 1998
21
11
Oct 1
21
11
Sep 1
21
11
Aug 1
21
11
Jul 1
21
11
Jun 1
11
21
May 1
Nov 1
11
Venus at greatest elongation on November 5/6
Looking west
30 minutes after sunset

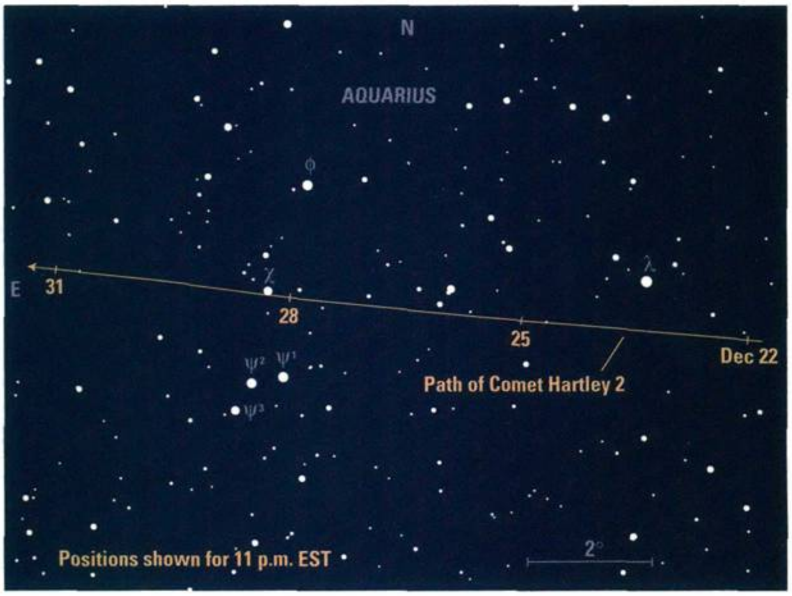
ASTRONOMY: Phil Kirchmeier

Edwin Faughn


July 15, 1997
Disk size = 11.5"
Magnitude = -3.9
August 15, 1997
Disk size = 13.1"
Magnitude = -4.0
September 15, 1997
Disk size = 15.8"
Magnitude = -4.1
October 15, 1997
Disk size = 20.0"
Magnitude = -4.2
November 15, 1997
Disk size = 27.8"
Magnitude = -4.5
December 15, 1997
Disk size = 43.1"
Magnitude = -4.7

ASTRONOMY: Elisabeth Rowan

# From Hale-Bopp to Hartley 2



ASTRONOMY: Elisabeth Rowan

You'll probably be dazzled by the Great Spring Comet of 1997. With splendid dust and ion tails, Comet Hale-Bopp is likely to outdo even 1996's exceptional Comet Hyakutake.

But for every barn-burner comet, dozens of fainter ones quietly roam the depths of our solar system, cataloged and waiting to be recovered. Modest Hartley 2 is just such a comet, one of several slated to return to earthly skies in 1997.

These returning comets are in reality quite different from ones like Hale-Bopp and Hyakutake. The latter take thousands of years to orbit the Sun; the former, a handful. Each trip past the Sun depletes more and more of the volatile material a comet needs to create a decent tail. Consequently the so-called "periodic comets" (as opposed to "long period" ones like Hyakutake) tend to only muster a warm glow from their well-worn surfaces.

So don't expect brightness from a periodic comet, but predictability. Hartley 2 makes a pass through Earth's neighborhood every 6.4 years. Where Hale-Bopp could top magnitude 0 with its relatively pristine nucleus, Hartley 2 will be lucky to reach naked-eye visibility at its best in late December.

Hartley 2 wasn't always relegated to such mediocrity. It, like the long-period comets, traces its origin to the Oort Cloud, a shell of dirty snowballs that surrounds our solar system out to a quarter of the way to the nearest star. But while most long-period comets tread our solar system unmolested, Hartley 2 got its orbit deflected by the gravity of an outer planet.

This nudge, and perhaps subsequent nudgings, made Hartley 2 into the periodic comet we see today. For the next several thousand years, it will glow through each pass near the Sun until all that can sublimate and glow gets burned off to leave a cinder.

As if paying silent tribute to this sacrifice, many telescopic observers track these interplanetary yeomen through pass after pass. Why not undertake your own homage? Pay close attention to ASTRONOMY's monthly Sky Almanac section for upcoming returns of other periodic comets during 1997.

## PERIODIC COMETS IN 1997

| Name | Perihelion | date |
|---|---|---|
| Shoemaker-Levy 4 | January | 11 |
| Russell 4 | February | 3 |
| Wirtanen | March | 14 |
| Hale-Bopp | April | 1 |
| Wild 2 | May | 6 |
| Encke | May | 23 |
| Hartley 1 | May | 28 |
| Gehrels 2 | August | 7 |
| Taylor | December | 12 |
| Hartley 2 | December | 21 |

Gerald Rhemann

Comet Hartley 2

## DECEMBER

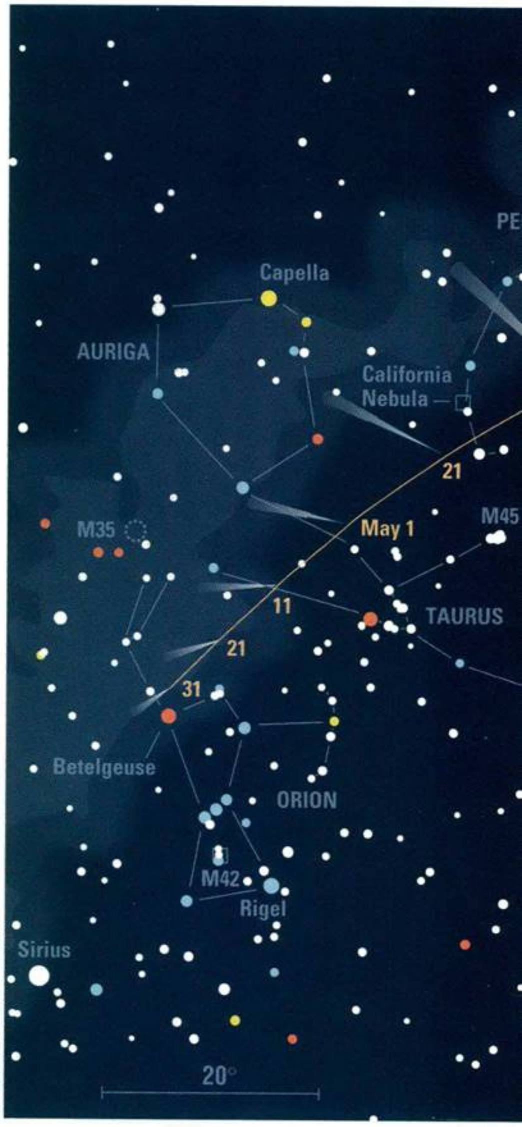
| S | M | T | W | T | F | S |
|---|---|---|---|---|---|---|
|  | 1 | 2 | 3 | 4 | 5 | 6 |
| ◐ | 8 | 9 | 10 | 11 | 12 | ○ |
| 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| ◑ | 22 | 23 | 24 | 25 | 26 | 27 |
| 28 | ● | 30 | 31 |  |  |  |

| Day | Time (EST) |
|---|---|
| 2 | **midnight**<br>**The Moon passes 5° north of Mars** |
| 3 | **noon**<br>The Moon passes 7° north of Venus |
| 5 | **3 a.m.**<br>The Moon passes 3° north of Jupiter |
| 9 | **2 a.m.**<br>**The Moon passes 0.2° north of Saturn** |
| 11 | **6 p.m.**<br>**Venus is at greatest brilliancy (magnitude –4.7)** |
| 12 | **midnight**<br>**The Moon passes 0.5° north of Aldebaran** |
| 13 | Geminid meteor shower peaks |
| 17 | **3 a.m.**<br>Mercury is in inferior conjunction |
| 21 | **3 p.m.**<br>Solstice (northern winter/southern summer begins) |
| 22 | **6 a.m.**<br>**Venus passes 1.1° north of Mars (evening)** |
| 27 | **10 p.m.**<br>The Moon passes 2° north of Mercury |
| 31 | **8 a.m.**<br>The Moon passes 1.3° north of Venus<br>**10 p.m.**<br>**The Moon passes 4° north of Mars** |

# Comet Hale-Bopp Arrives

by Richard Talcott

Gerald Rhemann and Franz Kersche



ASTRONOMY: Elisabeth Rowan

Comet watchers have seemingly lamented the dearth of bright comets ever since Comet West faded from view after its spectacular show in the spring of 1976. At least until last year, that is, when Comet Hyakutake reminded us how glorious a bright comet can appear. But Hyakutake was only a portent of things to come: If predictions hold true, 1997's Comet Hale-Bopp should be *the* comet of the 1990s.

Hale-Bopp begins the year among the background stars of Serpens Cauda, very low in the east as morning twilight commences. The 2nd- or 3rd-magnitude object should sport a short tail angling above and to the left of the comet's head.

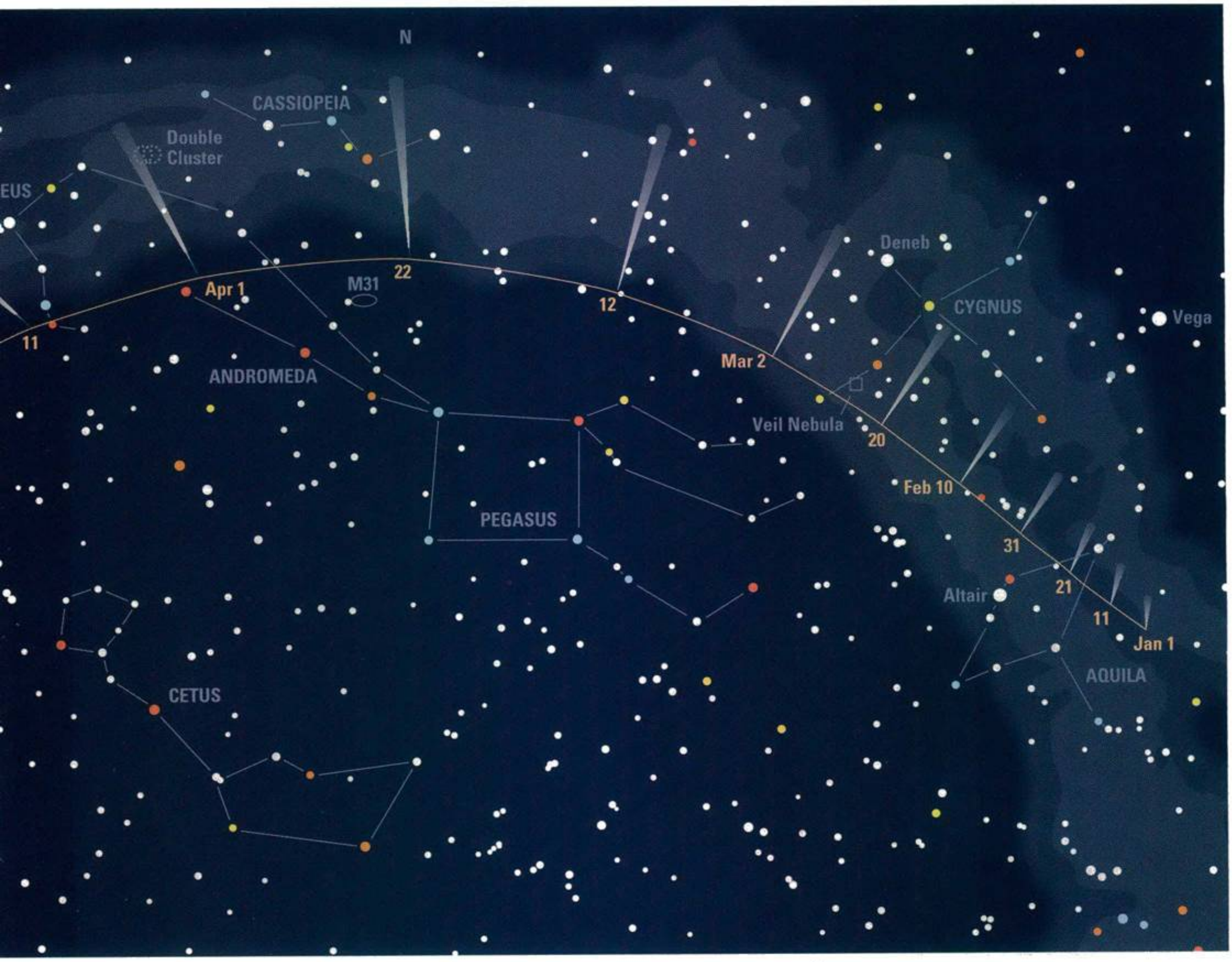
During the next few months, the comet grows brighter and its tail grows longer. But just as important, it moves quickly to the northeast, away from the Sun's glow and higher in the predawn sky.

Early February marks your first chance of 1997 to view Hale-Bopp significantly above the horizon with the Moon out of the morning sky. For the first three weeks of the month, in fact, it eludes interference from moonlight as it treks along the spine of the Milky Way from Aquila through Sagitta and into Vulpecula.

During this period, expect it to double in brightness, reaching about magnitude 0 (as bright as Vega, the brightest star in this part of the sky) toward the end of February. Its tail also lengthens, perhaps to 10° long, and points nearly straight up from the eastern horizon.

From late February until mid-April, the comet remains a stunning sight. Although moonlight occasionally interferes, it's not a major problem because the comet conveniently slips from the morning sky into the evening sky in the latter half of March, at about the same time that the Moon moves from evening to morning.

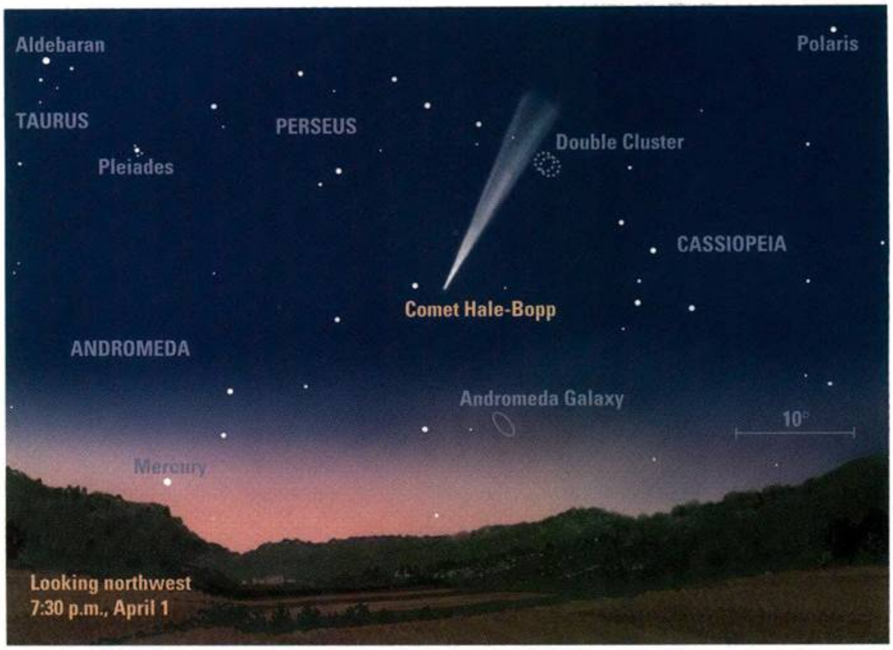
During this interval, the comet traverses Cygnus, Lacerta, Andromeda, and Perseus. It comes closest to Earth on March 22 (200 million kilometers), when it should display its longest tail


N
CASSIOPEIA
Double Cluster
EUS
Apr 1
M31
22
11
ANDROMEDA
12
Mar 2
Deneb
CYGNUS
Vega
Veil Nebula
20
Feb 10
PEGASUS
31
Altair
21
11
Jan 1
AQUILA
CETUS

of perhaps 20° or more. Over the next couple of nights, watch as the comet passes just 3° north of M31, the great spiral galaxy in Andromeda.

Between its closest approach to Earth and its closest approach to the Sun on April 1, the comet appears brightest. If predictions hold true, it should shine at about magnitude –1, rivaling Sirius and Mars as the brightest objects in the evening sky.

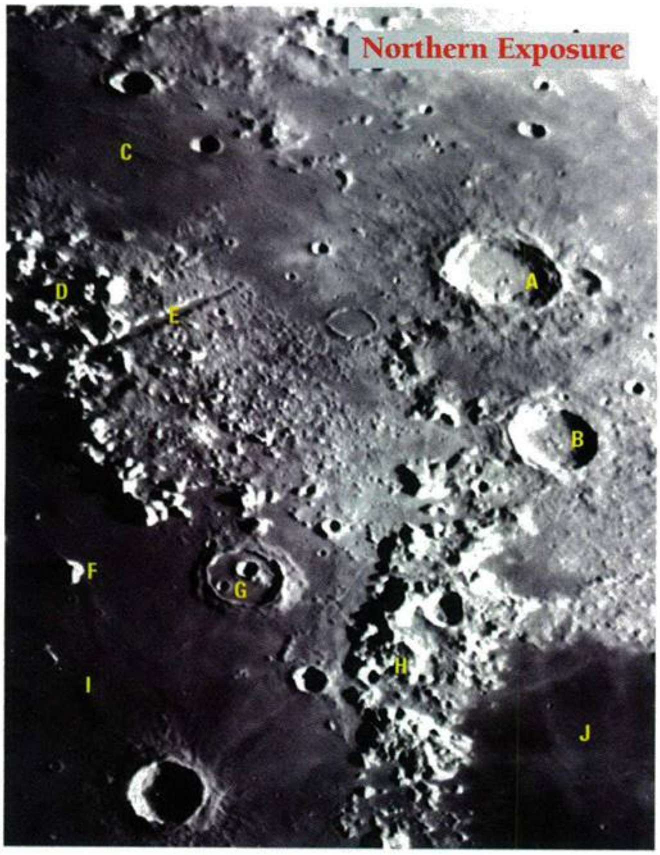
After the Moon exits the evening sky in late April, the comet returns to prominence, but not for very long. Although still bright (probably near 1st magnitude), it heads rapidly south through Taurus and Orion, sinking ever closer to the western horizon. By mid-May the comet will be lost in the Sun's glare, a mere memory perhaps, but a memory worth treasuring for a long time. ☐


Aldebaran
Polaris
TAURUS
PERSEUS
Double Cluster
Pleiades
CASSIOPEIA
Comet Hale-Bopp
ANDROMEDA
Andromeda Galaxy
10°
Mercury
Looking northwest
7:30 p.m., April 1

ASTRONOMY: Elisabeth Rowan

# The Moon From Your Backyard

by John Shibley

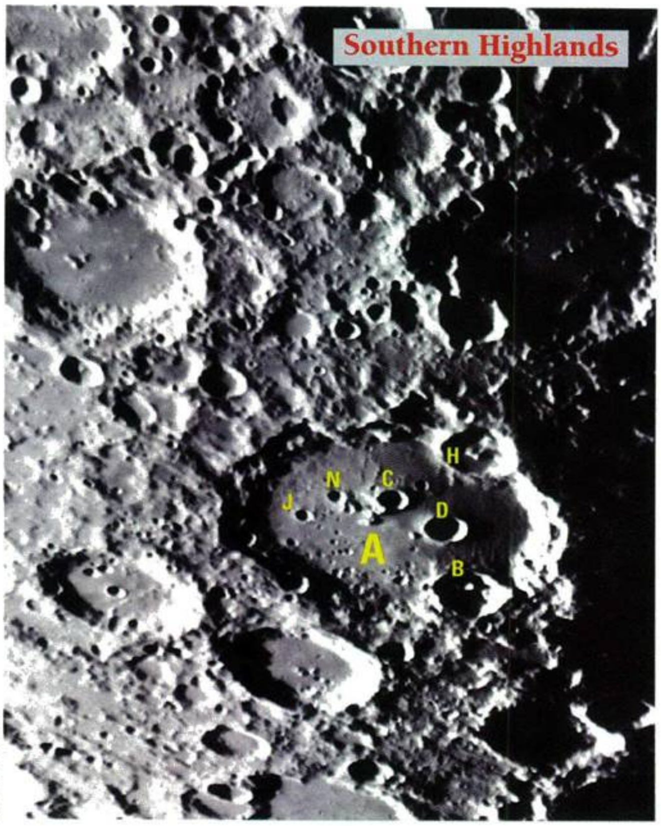


Leo Aerts

With its flooded lava plains, mountain chains, collapsed valleys and myriad craters, our nearest world the Moon, never fails to satisfy the backyard observer armed with a telescope. While every lunar observer has his or her favorite list of features, these four areas offer up a sampler of what awaits you during each and every lunation, from new Moon to new Moon.

### Seven Days after New Moon: Northern Exposure

By First Quarter the Moon's mid-northern latitudes come out of the lunar night into sunlight. To the north is 87-km-wide Aristoteles (A), with its terraced walls and 3,300-meter central peaks. Under low illumination, as in this photo, hillocks of material kicked out at impact come into view. Southeast of Aristoteles lies another well-defined crater called Eudoxus (B). Its 67-km diameter sports 3,000-meter walls. Connecting Mare Frigoris (C) to the Alpine Mountains (D), is the 250-km-long Alpine Valley (E). Over the mountain range and moving south onto Mare Imbrium, look for the top of mile-high Mt. Piton (F) glowing brightly in to the morning light. Due east of Piton lies Cassini (G), a flooded crater with two smaller craters on its floor. Continue in the same direction to the Caucausus Mountains (H), a distinct north-south chain that divides Mares Imbrium (I) and Serenitatis (J).



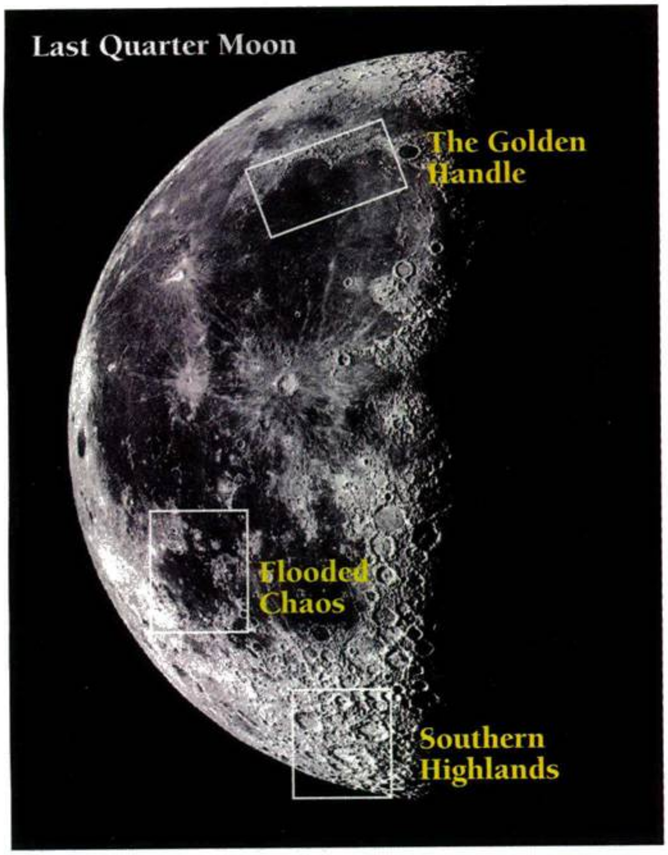
Christian Arsidi

### Day Nine: Southern Highlands

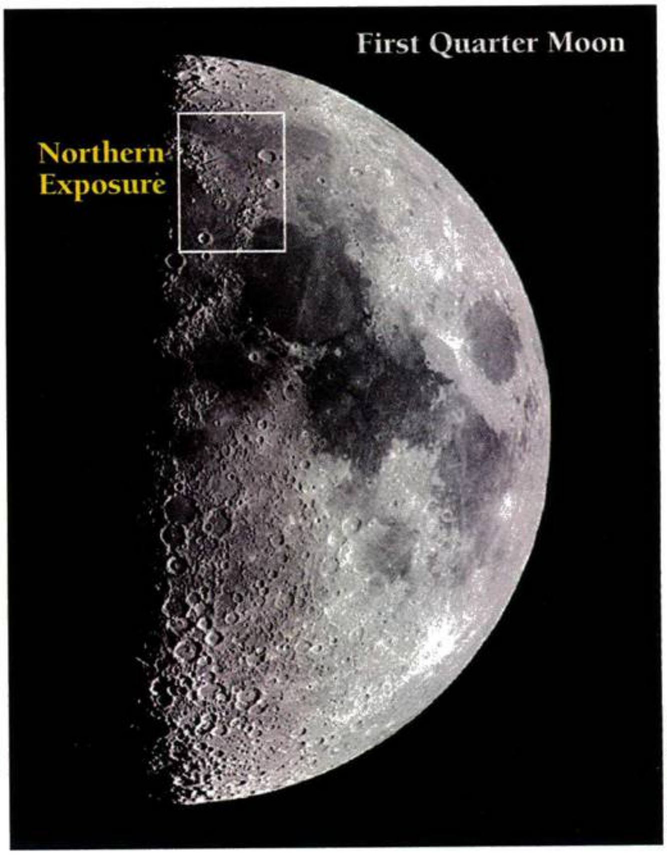
Two days after first quarter and day nine after new we are treated to the Moon's lunar highlands, an ancient, pummeled terrain more mountainous and rougher than the lower, smoother maria. One prominent crater, 225-km-wide Clavius (A), stands out among the others. Spot an interesting arc of craters arrayed along Clavius' floor that get progressively smaller from east to west. Start with 54-km-wide Rutherfurd (B) on the southeast rim, and move along to Clavius D, C, N, and J. If you can see 10-km-wide Clavius J, you've got a steady night indeed! Don't forget to take in the triple peaks of 52-km-wide Porter (H) imbedded in Clavius' northeast wall.

### Day 10: The Golden Handle

Sinus Iridum, the Bay of Rainbows (A), takes a bite out of Mare Imbrium's northern rim. While the bay's floor still lies cloaked in darkness, the Jura Mountains (B) catch the Sun's intense light after spending more than two weeks in lunar night. Observers coin the mountains in sunrise as the "Golden Handle," since this blazing range looks like a crimson-white handle attached to Imbrium's vast expanse. Two craters, Helicon (C; 25 km wide) and le Verrier (D; 20 km) seemingly guard the bay's entrance. East of Iridum, barely into Imbrium's plains, find a straight, rectangular 90-km-long mountain array called the Straight Range (E).


Last Quarter Moon
The Golden Handle
Flooded Chaos
Southern Highlands

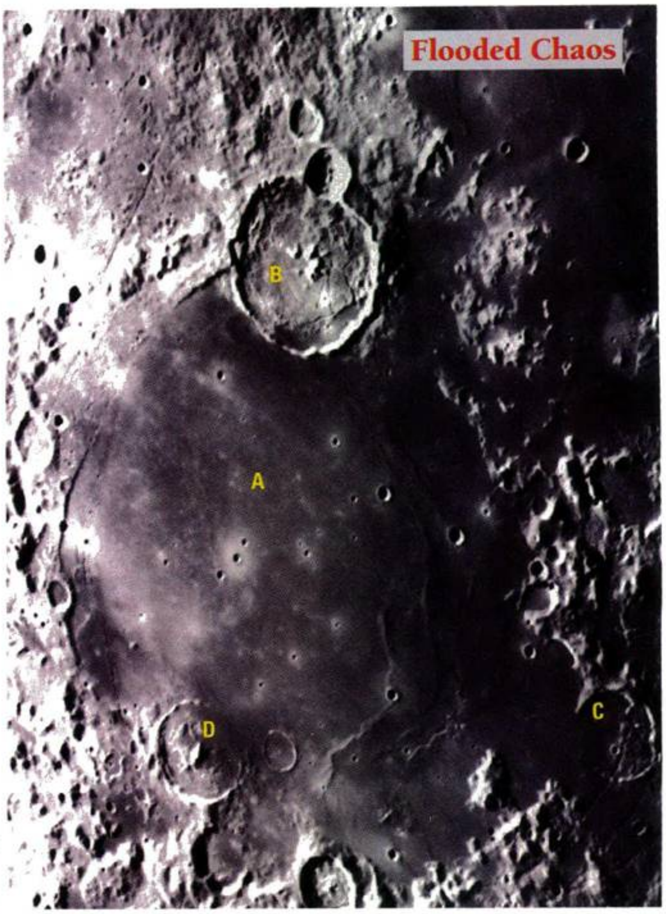
Lick Observatory


First Quarter Moon
Northern Exposure

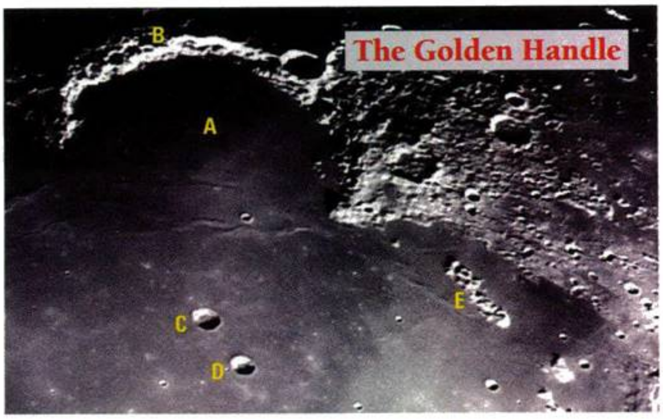
Terence Dickinson

## Day 11: Flooded Chaos

Here we find Mare Humorum (A), a great flooded basin that measures 380 km in size. Under low light, look for wrinkle ridges along its floor, the effects of lava that cooled, shrank, and slumped. Gassendi (B) hangs on Humorum's northeast rim, a 110-km-wide crater riddled with crack-like rilles (another effect of cooling and slumping) and a network of 4,000-foot central peaks. A 4-inch scope is more than adequate to reveal Gassendi's family of rilles. Look along Humorum's southeast shore for three concentric rilles that are hundreds of kilometers long and bisect an ancient, flooded crater called Hippalus (C). Humorum's southwest shore harbors another, more well-defined flooded crater called Doppelmayer (D). Both of these craters had their walls breached when Humorum flooded with lava more than three billion years ago. □


Flooded Chaos
B
A
D
C

Gérard Therin


The Golden Handle
B
A
C
D
E

Jean Dragesco

# The Wonderful Spirals of Spring

**M101 in Ursa Major**
*Bill and Sally Fletcher*

**M81 and M82 (top) in Ursa Major**
*Mike Mayerchak*

**NGC 4565 in Coma Berenices**
*Jack Marling*

Springtime means warm breezes, cherry blossoms, babbling streams of melted snow, and, high overhead at night, galaxies by the hundreds. Our nightly perspective looks out from a dusty Milky Way into the universe beyond. And what else lies beyond but more cousins to our own galaxy?

Start your galaxy tour northwest of the Big Dipper in Ursa Major with M81 and M82, each separated by just over the width of a Full Moon. M81 reveals itself through a telescope as a graceful spiral, while cigar-shaped M82 looks wracked by episodes of star formation. Both galaxies are 6.5 million light-years away.

Now shift to just above the Dipper's handle to where M101, a face-on spiral galaxy, covers an area of sky ⅔ the Moon's diameter. Glowing gas clouds mark where new stars are lighting up for the first time. These bright gas clouds have received catalog designations of their own, along with their parent galaxy.

Move south into the constellation of Coma Berenices, itself a 5°-wide open star cluster. Less than a billion years ago Coma's young stars emerged from a cloud similar to the ones seen in M101.

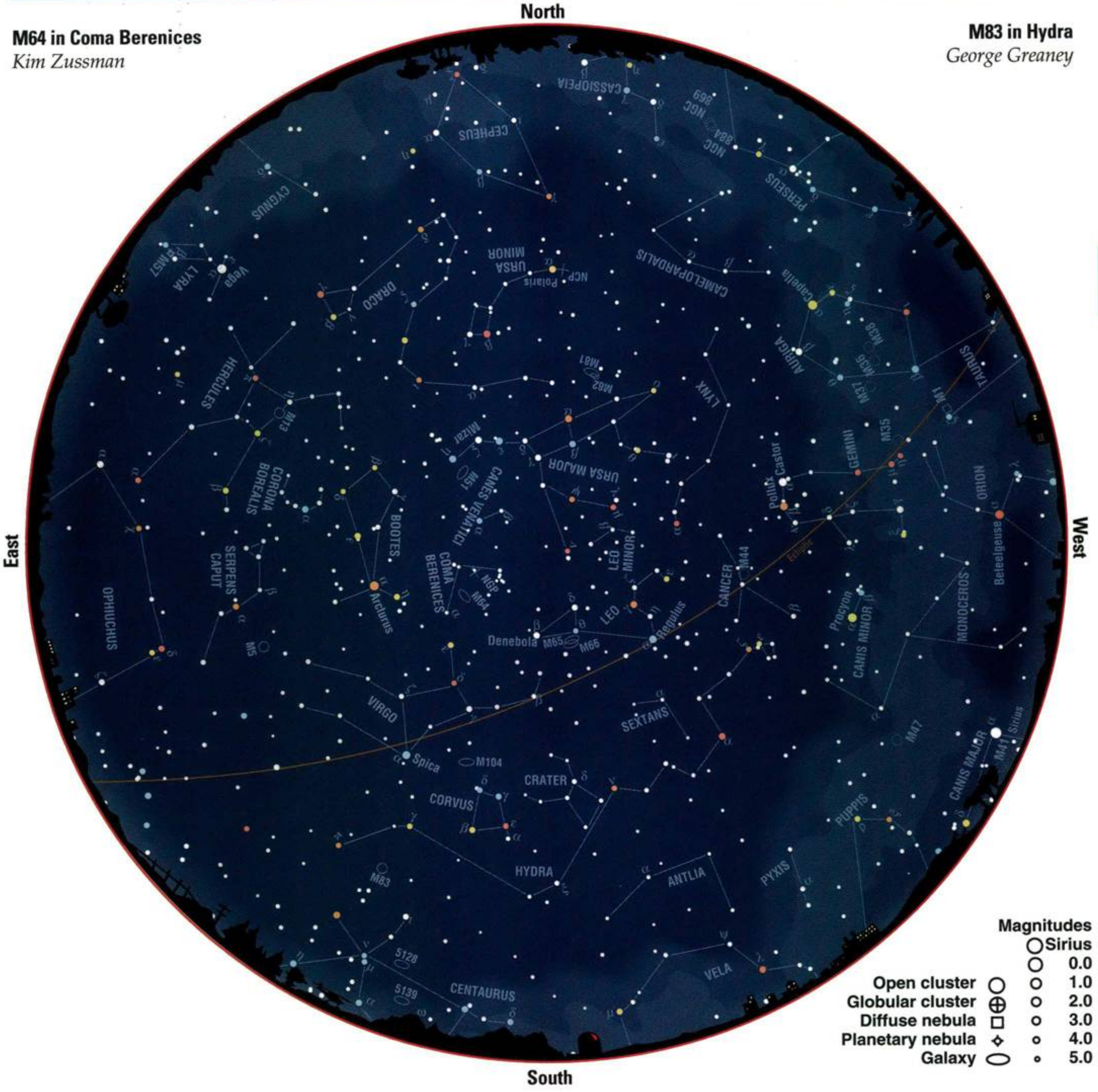
Just east of the constellation's center we come across an edge-on spiral galaxy called NGC 4565. A 6-inch scope reveals a needle-like shape; larger scopes show dark, dusty clumps of dust along its length.

For another look at a dusty galaxy, move southwest to M64, where our vantage point is more face-on. A huge glob of dust borders the northeast side of M64's nucleus, giving it the "Blackeye Galaxy" nickname.

We round off our spring galaxy jaunt in Hydra, where M83 shines across 10 million light-years of space. It's a spiral galaxy like our own Milky Way that appears face-on through a telescope. But the similarities end there. With a diameter of 30,000 light-years, M83 is a mini Milky Way only ⅓ the size of our home galaxy.

**M64 in Coma Berenices**
*Kim Zussman*

**M83 in Hydra**
*George Greaney*


North
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CASSIOPEIA
CEPHEUS
NGC 869
NGC 884
PERSEUS
CYGNUS
LYRA
M57
Vega
DRACO
URSA MINOR
NCP
Polaris
CAMELOPARDALIS
Capella
AURIGA
M38
M36
M37
TAURUS
M1
HERCULES
M13
M81
M82
LYNX
Mizar
URSA MAJOR
M51
CANES VENATICI
CORONA BOREALIS
BOOTES
Arcturus
COMA BERENICES
NGC 4565
M64
LEO MINOR
Castor
Pollux
GEMINI
M35
ORION
Betelgeuse
SERPENS CAPUT
M5
OPHIUCHUS
CANCER
M44
Ecliptic
Procyon
CANIS MINOR
MONOCEROS
LEO
Regulus
Denebola
M65
M66
VIRGO
SEXTANS
M47
Sirius
M41
CANIS MAJOR
Spica
M104
CRATER
CORVUS
HYDRA
ANTLIA
PYXIS
PUPPIS
M83
5128
5139
CENTAURUS
VELA
Magnitudes
Sirius
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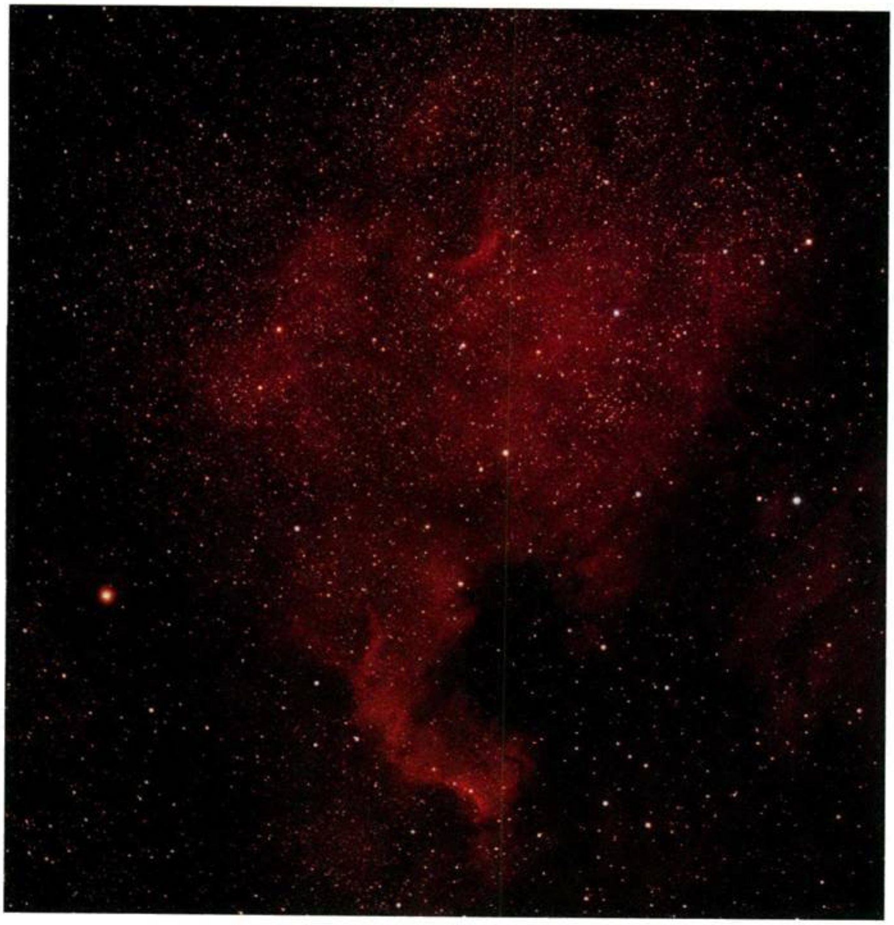
Open cluster
Globular cluster
Diffuse nebula
Planetary nebula
Galaxy

# Summer's Cadence of Death and Rebirth



**The North America Nebula in Cygnus**
*George Vlahakis*

**M6 (top) and M7 in Scorpius**
*Paul Burke*

**Open Cluster M11 in Scutum**
*Jack Newton*

All along the summer Milky Way's spine we witness the cycle of life and death within a typical spiral galaxy. Young stars nestled in celestial nurseries of dust and gas light up their cocoons. Millions of years will pass before the primordial clouds lift to reveal young star clusters.

Depending upon size, some stars will take billions of years to end up as glowing cinders. Much larger ones will consume their fuel in a multimillion-year binge that culminates with a supernova. These exploding stars seed our galaxy with the heavier elements needed for solar systems yet to come.

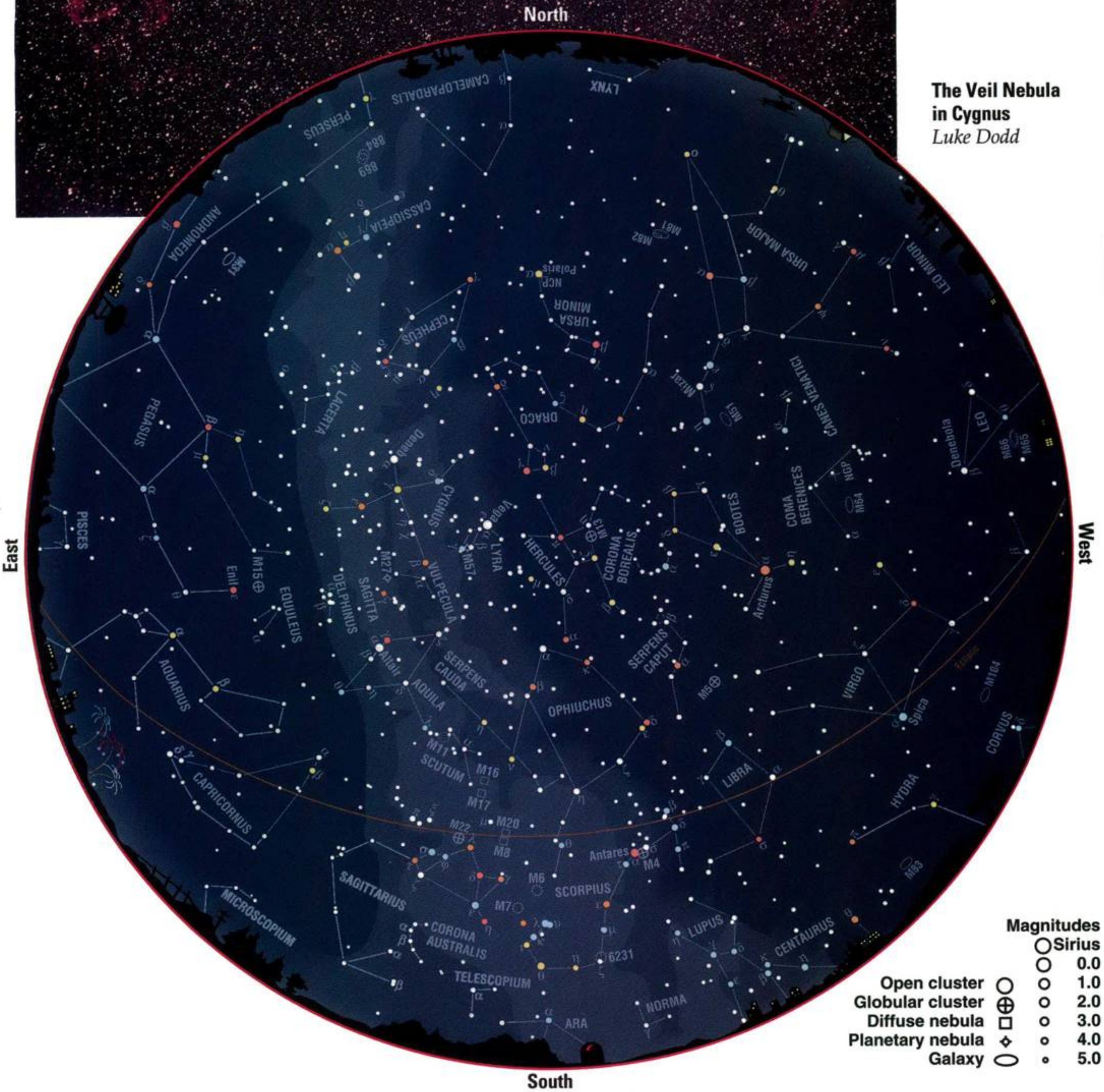
Cygnus harbors two objects on opposite ends of such an evolutionary journey. Just 3° east of Deneb lies the North America Nebula, so named due to its uncanny resemblance to the continent. This huge tract (the size of six Full Moons) of gas glows under ultraviolet light from nearby, newly-formed stars. Use binoculars under completely dark, rural skies to spot this elusive, gray glow.

Moving 14° south we come upon the antithesis of stellar birth: a supernova remnant. The Veil Nebula is the glowing shock wave from a stellar explosion that happened 30 to 40 thousand years ago. As this wave expands through the interstellar medium, it compresses dark areas of gas and dust into making new star systems of their own.

In between this cycle of creation and demise lie the stars themselves, the youngest of which tend to remain in clusters until gravity combines with time to scatter them into intragalactic space.

In Scutum, just beneath Aquila, we see the glittering star cluster M11, a gem for small telescopes. Farther to the south, near Scorpius the Scorpion's stinger we glean a fine pair of binocular open clusters called M6 and M7. Northernmost M6 sports a butterfly shape in its star pattern, while M7 looks coarser and more spread out than its companion. M6 was created 100 million years ago, while the stars in M7 coalesced 240 million years ago.

**The Veil Nebula in Cygnus**
*Luke Dodd*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PERSEUS
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CASSIOPEIA
ANDROMEDA
M31
PEGASUS
PISCES
CEPHEUS
LACERTA
URSA MINOR
NCP
Polaris
M81
M82
URSA MAJOR
LEO MINOR
LEO
Denebola
M65
M66
DRACO
Mizar
M51
CANES VENATICI
COMA BERENICES
NGP
M64
BOOTES
Arcturus
CORONA BOREALIS
HERCULES
M13
LYRA
Vega
M57
CYGNUS
Deneb
VULPECULA
M27
SAGITTA
DELPHINUS
EQUULEUS
M15
Enif
AQUARIUS
CAPRICORNUS
AQUILA
Altair
SERPENS CAUDA
SERPENS CAPUT
M5
OPHIUCHUS
VIRGO
Spica
M104
CORVUS
Ecliptic
SCUTUM
M11
M16
M17
M20
M22
M8
M6
M7
SCORPIUS
Antares
M4
LIBRA
HYDRA
M83
SAGITTARIUS
MICROSCOPIUM
CORONA AUSTRALIS
TELESCOPIUM
6231
LUPUS
CENTAURUS
NORMA
ARA
Magnitudes
Sirius
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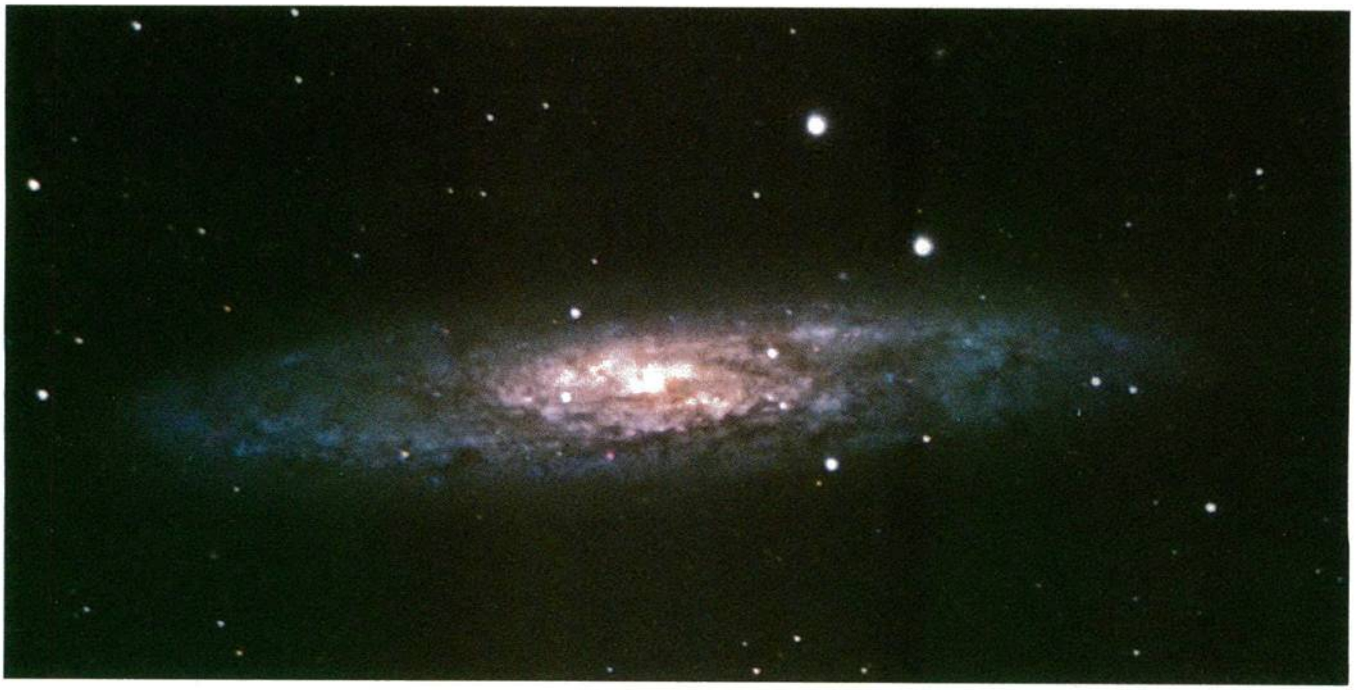
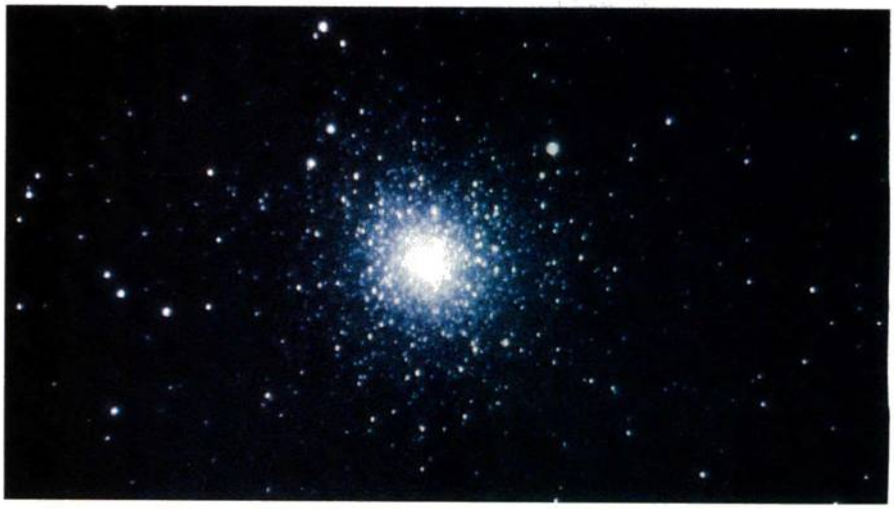
3.0
4.0
5.0
Open cluster
Globular cluster
Diffuse nebula
Planetary nebula
Galaxy

# Autumn's Time of Transition



**NGC 253 in Sculptor**
*Bob and Janice Fera*



**M2 in Aquarius**
*Bill Iburg*

The autumnal skywatcher straddles two celestial realms, two regions with a distinct character that sets them off from one another. Summer embraces the plane of our Milky Way, along with all the objects associated with a typical galaxy such as globular clusters, open clusters, and planetary nebulae. The fall sky, on the other hand, faces intergalactic space, far from the din of a crowded home galaxy. When we look into the stars of fall, we quite literally face off with infinity.

But right after sunset, things closer to home hold our attention, like the globular cluster M2 in Aquarius. About 300 of these ancient clusters orbit the hub of our galaxy; M2 stands off from a distance of 36,500 light-years. The latest theories suggest it and its brethren formed many billions of years ago when our Milky Way interacted with another galaxy.

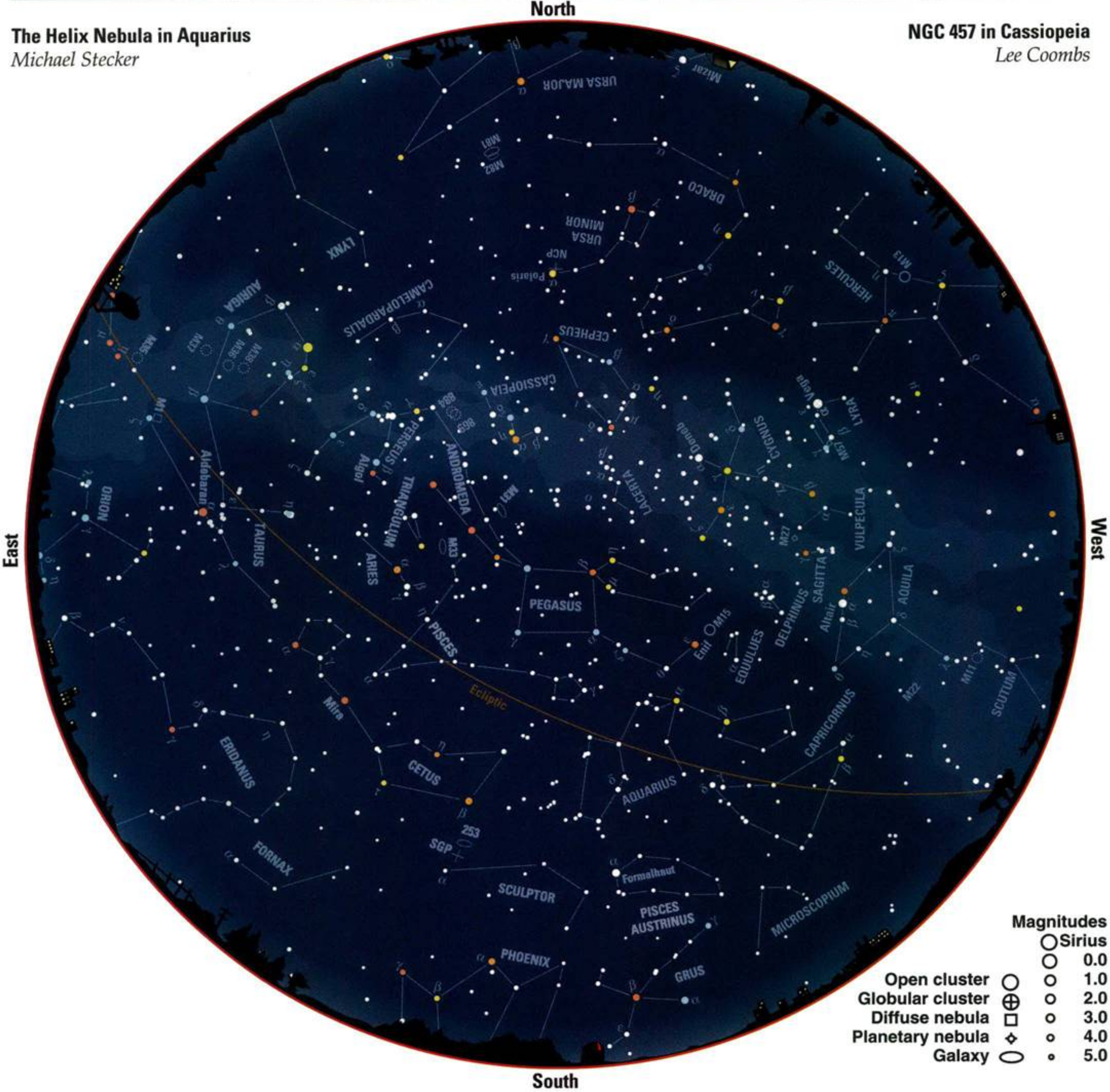
Some 24° to the southeast lies another galactic object, this one spawned by the death of an average-sized star. NGC 7293, The Helix Nebula, is an expanding gas shell puffed off by a star in the final years of life. Ultraviolet radiation cranked out by the dying star makes the shell glow. Travel far away from city lights and use binoculars to glimpse this ghostly behemoth.

Just about as far south but farther to the east in Sculptor is NGC 253, a dusty, spiral galaxy slightly banked to our line of sight. This area of the sky looks out 90° from the plane of our galaxy, and NGC 253 is just one of hundreds of other "island universes" glimpsable through a backyard telescope. This galaxy, however, is one of the more obvious ones, shining across 9.7 million light-years of space.

As the fall night sky wheels west, the plane of our galaxy rises once more in the east. Now we start running into galactic citizens like open clusters again. The outline of one, NGC 457 in Cassiopeia, looks for all the world like a lobster or an owl. Can you spot a similarity? Hint: Two bright stars mark the eyes.

**The Helix Nebula in Aquarius**
*Michael Stecker*

**NGC 457 in Cassiopeia**
*Lee Coombs*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Mizar
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HERCULES
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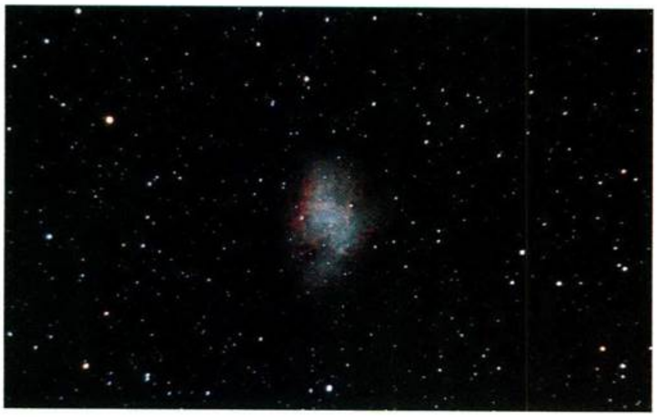
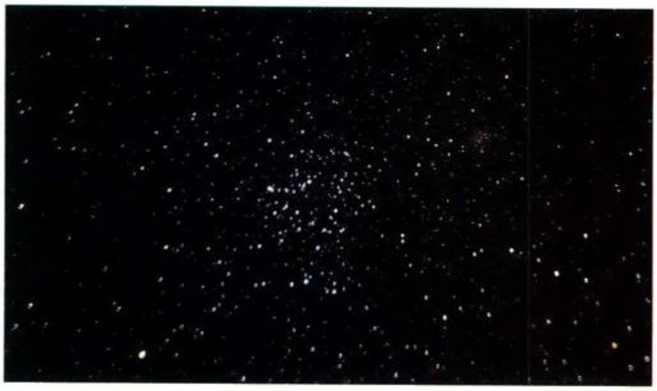
Algol
LYRA
Vega
M57
CYGNUS
Deneb
LACERTA
ANDROMEDA
M31
TRIANGULUM
M33
ORION
M1
Aldebaran
TAURUS
ARIES
VULPECULA
M27
SAGITTA
Altair
AQUILA
DELPHINUS
EQUULEUS
Enif
M15
PEGASUS
PISCES
SCUTUM
M11
M22
Ecliptic
Mira
CETUS
ERIDANUS
CAPRICORNUS
AQUARIUS
253
SGP
FORNAX
SCULPTOR
Fomalhaut
PISCES AUSTRINUS
MICROSCOPIUM
PHOENIX
GRUS
Magnitudes
Sirius
0.0
1.0
2.0
3.0
4.0
5.0
Open cluster
Globular cluster
Diffuse nebula
Planetary nebula
Galaxy

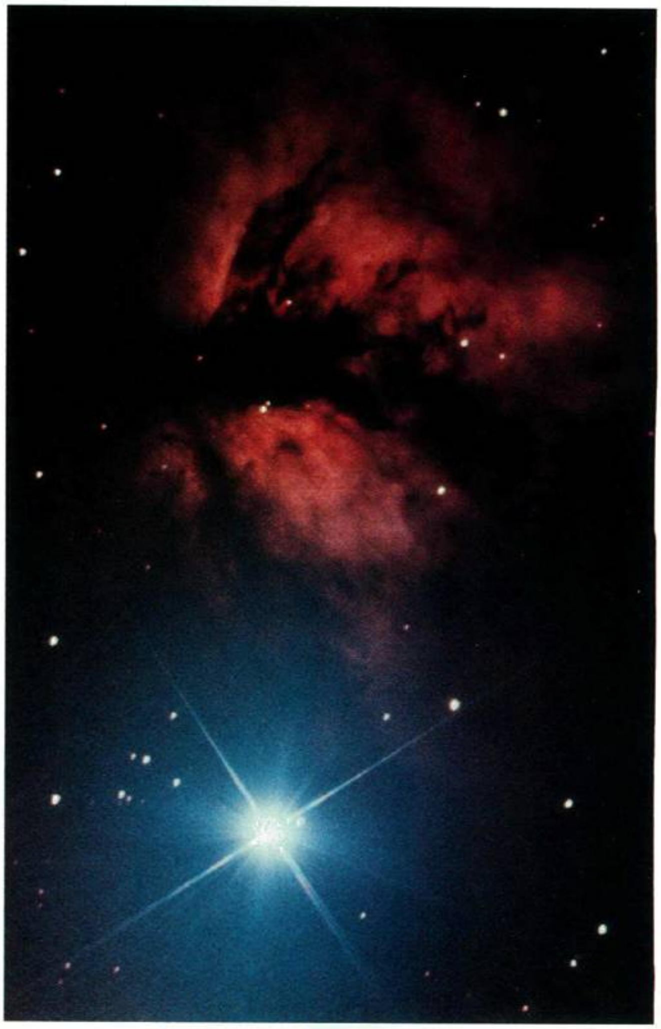
# Winter's Undiscovered Milky Way



**M1 in Taurus**
*Bill Iburg*



**M35 in Gemini**
*Mace Hooley*



**NGC 2024 in Orion**
*Jack Newton*

Many seasoned observers forget that winter is also for Milky Way lovers. Sure summer is richer, but that's because we're looking into an adjacent spiral arm bursting with star formation. In winter we look into our own arm and into the next one out, which is more distant and largely obscured. For sure, there isn't as much action, but there are sights to behold for skywatchers willing to brave the nippier temps of winter.

Let's start with the sky itself. There are many more stars brighter than 1st magnitude than the number we see in the summer sky. This is because we're facing many more closer, and bigger, stars that inhabit our own Cygnus spiral arm. Aside from that, we see many more open star clusters in winter than in summer.

Two of them, M46 and M47 in Puppis, fit comfortably into the field of a low-power telescope. Can you see the planetary nebula, a dying star's last puff of gas, superimposed along our line of sight with M46?

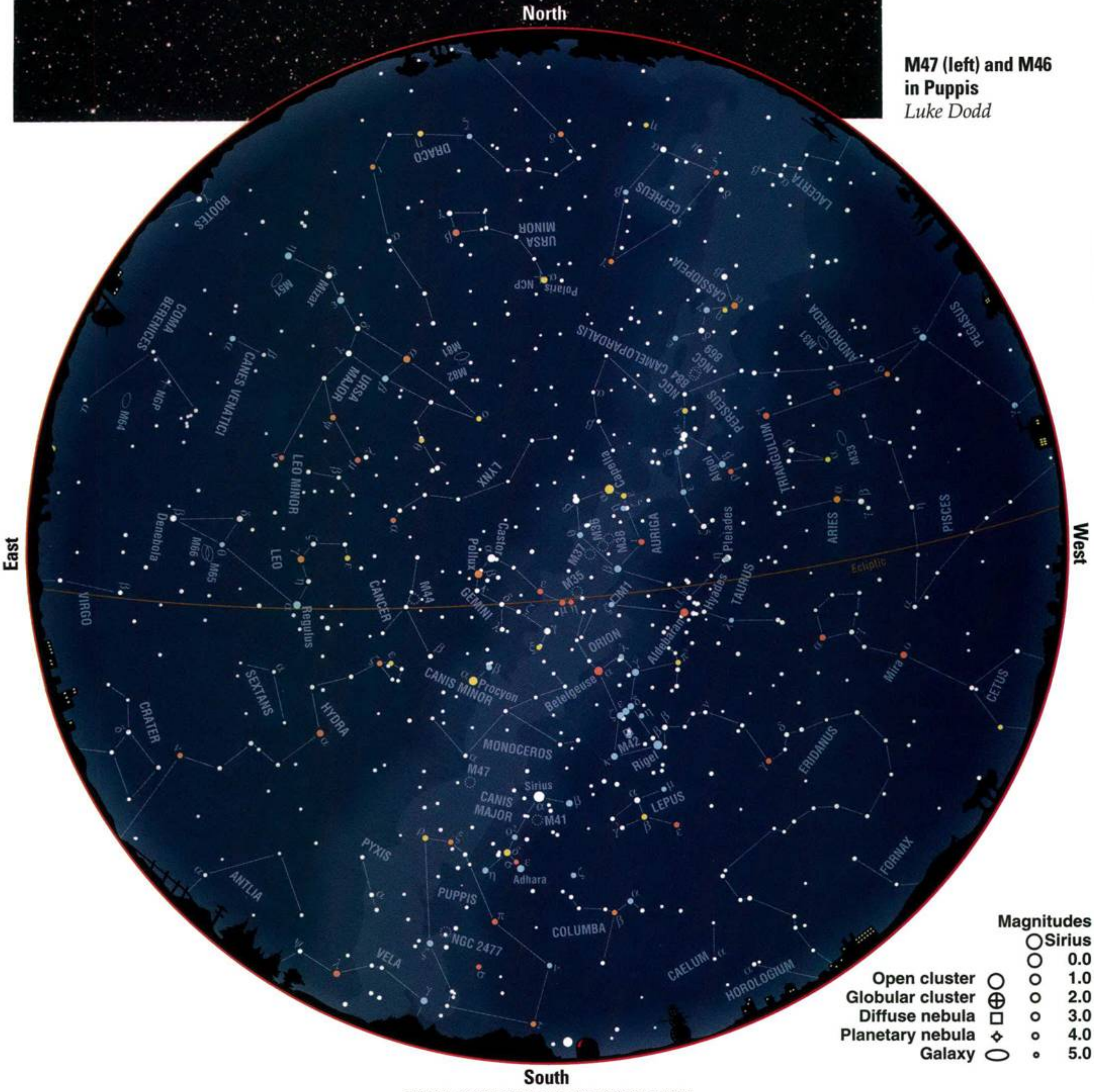
To the north in Gemini lies another cluster, M35. Observers with keen eyesight might spot tiny NGC 2158 in the same field of view. Where M35 resides in our arm at a distance of 2,800 light-years, NGC 2158 shines from the next spiral arm out at 16,000 light-years.

To the west, in Taurus the Bull, we come across a tiny supernova remnant called M1, or the Crab Nebula. M1 is a maelstrom of gas irradiated by a tiny neutron star, the condensed remains of a gigantic star that exploded on July 4, 1054. One teaspoon of neutron starstuff weighs several tons.

Finally, head south to the easternmost star in Orion's belt, Alnitak or Zeta (ζ) Orionis. Position it in a telescope just out of the southern field of view to see NGC 2024, the Flaming Tree Nebula.

Alnitak bathes this region of space with enough ultraviolet radiation to make normally-dark gas light up, creating our rather fanciful interpretation of a flaming tree. Your other choice is the Tank Tread Nebula. Honest.

M47 (left) and M46 in Puppis
*Luke Dodd*


North
DRACO
CEPHEUS
LACERTA
BOOTES
URSA MINOR
Polaris NCP
CASSIOPEIA
M51
Mizar
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CANES VENATICI
NGP
M64
URSA MAJOR
M81
M82
CAMELOPARDALIS
NGC 869
NGC 884
PERSEUS
ANDROMEDA
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PEGASUS
TRIANGULUM
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Algol
Capella
LYNX
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Pleiades
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Castor
Pollux
Denebola
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M65
LEO
East
West
VIRGO
Regulus
CANCER
M44
GEMINI
M35
TAURUS
Hyades
Aldebaran
Ecliptic
ORION
Betelgeuse
Procyon
CANIS MINOR
SEXTANS
HYDRA
Mira
CETUS
CRATER
MONOCEROS
M42
Rigel
ERIDANUS
M47
Sirius
CANIS MAJOR
M41
LEPUS
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Adhara
FORNAX
ANTLIA
PUPPIS
COLUMBA
NGC 2477
VELA
CAELUM
HOROLOGIUM
South
Magnitudes
Sirius
0.0
1.0
2.0
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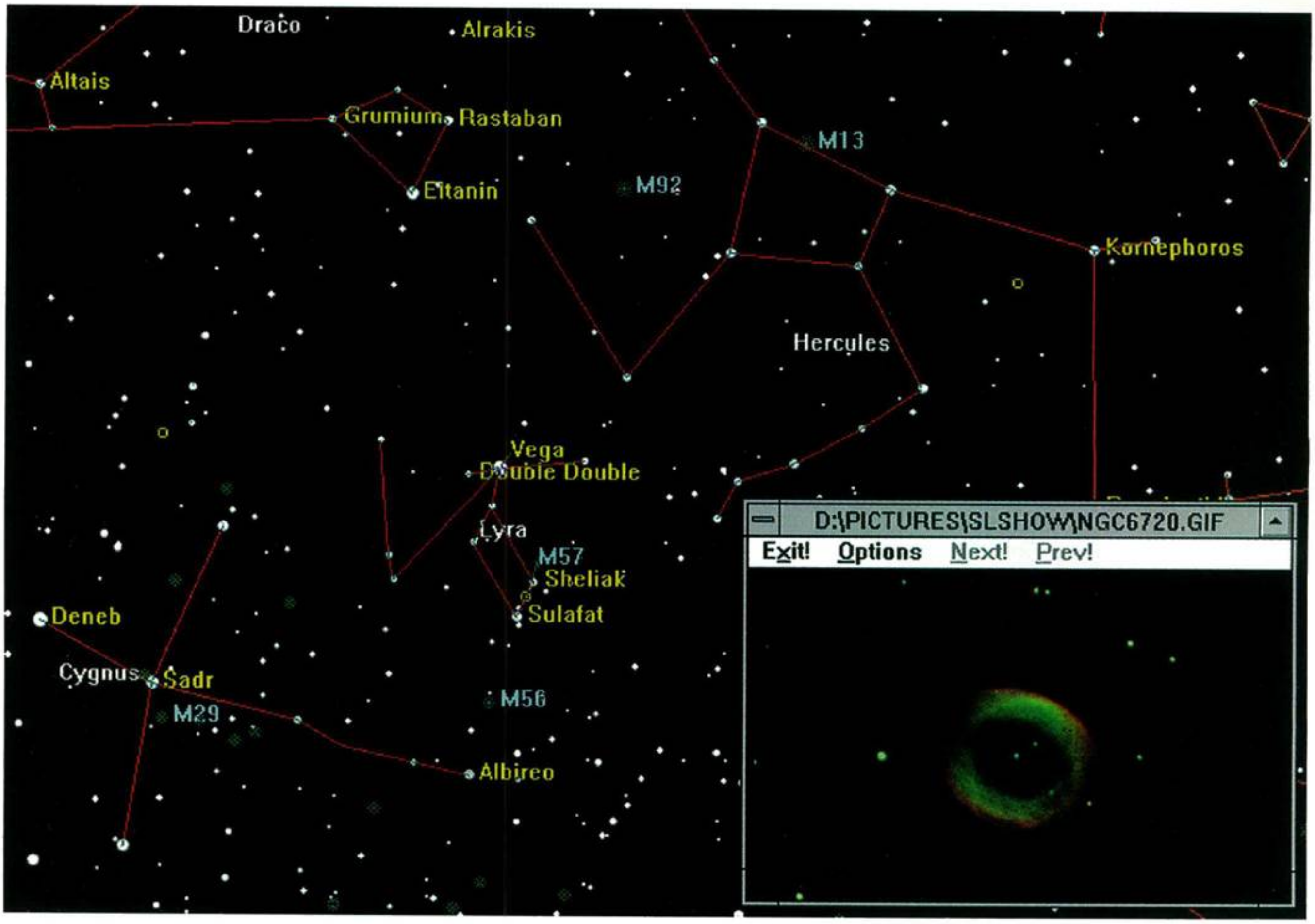
Open cluster
Globular cluster
Diffuse nebula
Planetary nebula
Galaxy

# EXPLORING THE VIRTUAL UNIVERSE

*Computers can help you see the universe in new ways, plan observing sessions, and glean news about the latest discoveries.*

by David Bruning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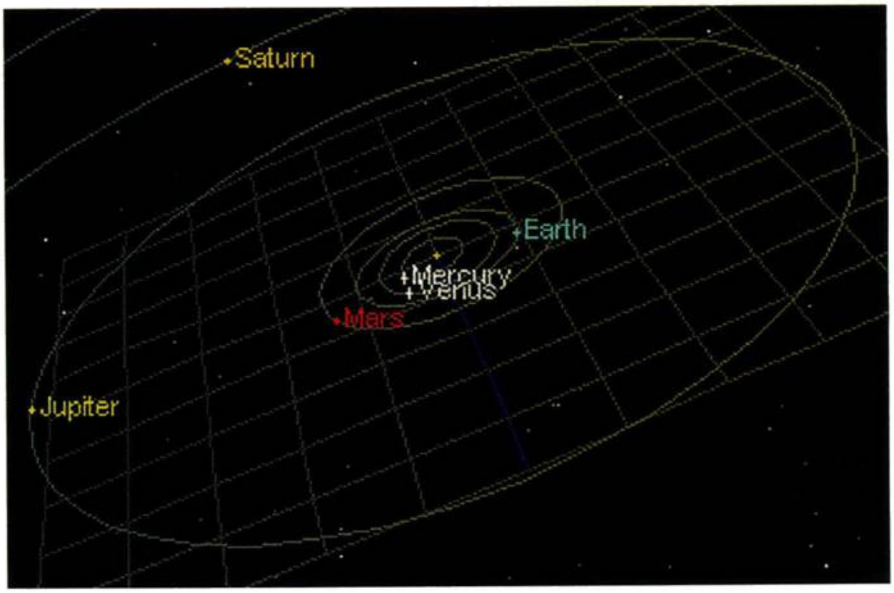
**Uncover deep-sky objects hidden among the constellations using a planetarium program such as *TheSky* (Windows). Printing out the chart can help locate an object through a telescope.**

Tonight's another cloudy night, robbing you of views of your favorite deep-sky objects and the bright comet you've heard so much about. Rather than watch television, you still want to feed your astronomical appetite. As your gaze sweeps the room, you spot the computer in the corner the kids play games on. Can't this expensive electronic gizmo be used for astronomy?

It sure can. Okay, so it won't present views to rival the night sky. But it will help you learn more about astronomy, keep observing notes, and



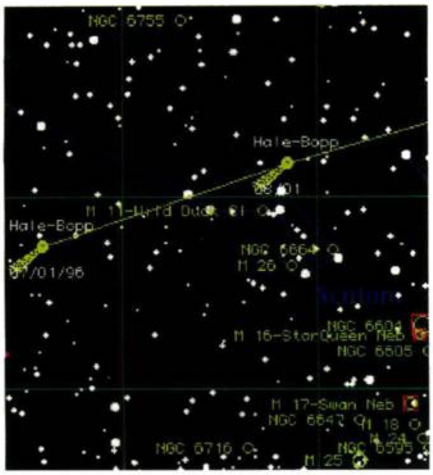
**Intrigued by planetary orbits? View the planets from any location using a planetarium program such as Distant Suns-First Light (Windows).**

uncover places in the sky to look for exciting objects. Some programs can even control your telescope on those nights when the weather is prime for observing.

Most hobbyists, from armchair astronomers seeking to learn more about the universe to observers equipped with binoculars and telescopes, start with a planetarium program. This software displays the sky in different ways to help you find planets, stars, constellations, galaxies, and nebulae. It can predict eclipses and the best time to view a celestial object. A guide to purchasing a planetarium program appears below.

But astronomy software doesn't stop there. Multimedia programs provide tours of the solar system and beyond. CD-ROMs (compact disk, read only memory) can store hundreds of images for viewing. Newer disks also contain movies of planetary fly-bys, Apollo astronauts landing on the Moon, and space shuttle missions. See "Images, Movies, and Multimedia" for a list of selected astronomy CD-ROMs.

More and more hobbyists of all types are finding that the Internet contains a wealth of information, and astronomy is no exception. This world-wide network of computers enables users to see the latest images from the Hubble Space Telescope, discover what's happening with the Galileo space probe now orbiting Jupiter, find out how to choose binoculars and telescopes, take a tour of the solar system, and learn about planets orbiting other stars. See "Net the Cosmos" for a list of sites to start your Internet tour of the universe.



**Predict celestial events such as the passage of Comet Hale-Bopp by the Wild Duck Cluster with a planetarium program such as Observer (Macintosh).**

## Your Own Home Planetarium

Open a window to the universe with a planetarium program. Such a program can indicate the planets' positions each night, locate deep-sky objects such as nebulae and galaxies, and create finder charts for use at the telescope. It can also display the distribution of star clusters throughout the Galaxy, animate the motions of planets through the sky, and show the planets as they appear from different positions within the solar system.

To choose a planetarium program, first consider your computer system: how much memory it has, whether you have a CD-ROM drive, which display you have, and of course whether you have a Macintosh or PC. If cost is a factor, choose a program that offers optional databases to be added later.

With hardware matters out of the way, the next two most important choices are the user interface and the astronomical phenomena displayed. User interface is probably the biggest reason why there isn't just one planetarium program on the market. Some folks prefer a simpler interface while others want a graphical interface. Pictures in the AstroBytes column of ASTRONOMY might help you choose; some software developers provide a demo version of their program so you can try it out.

Astronomers generally pick a planetarium program based on the observing they want to do or the phenomena they want to explore. Most programs show the planets, bright stars, and some deep-sky objects, but they differ in how they show planetary orbits and the number of celestial objects displayed.

For stars, many programs use the *Bright Star Catalog*, or a portion of this catalog, to show the positions and brightnesses of over 9,100 stars brighter than about magnitude 6.5. Others use the 250,000 stars of the Smithsonian Astrophysical Observatory (SAO) star catalog, extending the brightness limit below 8th magnitude. Currently, more programs are including the *Hubble Guide Star Catalog* with its over 15 million stars or permit adding this catalog as an option. A CD-ROM drive is needed to read this catalog.

The positions and brightnesses of galaxies, nebulae, and star clusters form a program's deep-sky object database. Some programs display only Charles Messier's catalog of 110 objects. Most use part or all of the *New General Catalogue* that lists almost 8,000 objects. Deep-sky observers focus their attention on a few programs that add other catalogs to

## Choosing a Planetarium Program

Here are a few points to consider when selecting a planetarium program to be sure it runs on your computer system and that it will meet your astronomical needs.

**Hardware**

- Processor speed required
- Memory required
- Hard disk space required
- CD-ROM drive required?
- Operating system supported?
- Monitor supported?
- Printer supported?

**Astronomical considerations**

- Number of stars displayed
- Number of deep-sky objects displayed
- Number of comets and asteroids displayed
- Satellites of planets displayed?
- Optional stellar or deep-sky databases?
- Chart customizing?
- Telescope control?
- Observing planner?

include fainter nebulae, galaxies, and star clusters. These programs allow users to customize the database to display only double stars, supernovae remnants, open star clusters, globular star clusters, or certain types of galaxies. Some programs show the actual size of an object, which is useful when tracking down a faint, fuzzy galaxy. Deep-sky observers should check that the program can display finder charts, reverse the field to match an eyepiece or finder view, and display a circle to represent an eyepiece field of view.

Asteroid and comet observers should check whether the program has a closed database of objects or whether they can add newly discovered objects to it. Planetary observers may want to check whether the program displays the satellites of the planets. Most programs can animate the motions of solar system events such as the next solar eclipse or the path of an upcoming planetary or asteroid opposition. The animation feature can also find conjunctions (groupings of the planets in the sky).

Many planetarium program users enjoy having the software display images of the planets and deep-sky objects. These graphical features appeal greatly to organizers of Astronomy Day programs, club events and school presentations.

Finally, those who own a computerized scope can run it with many planetarium programs. Simply select the desired object on the screen with the cursor and click the mouse button to send the telescope on its way to the object. Check with the software developer to see if the program will work with your scope model.

Once you get hooked into doing astronomy with your computer, you may want to explore other avenues of astronomical computing. Many folks enjoy enhancing images with image-

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Windows-compatible sound card

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http://www.infinet.com/~galactic/products/cd-rom.html

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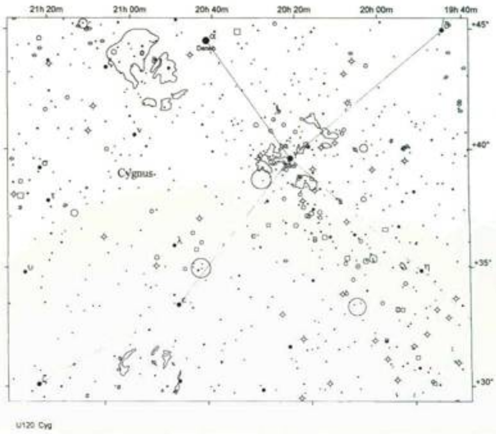

**Laptop Owners:**

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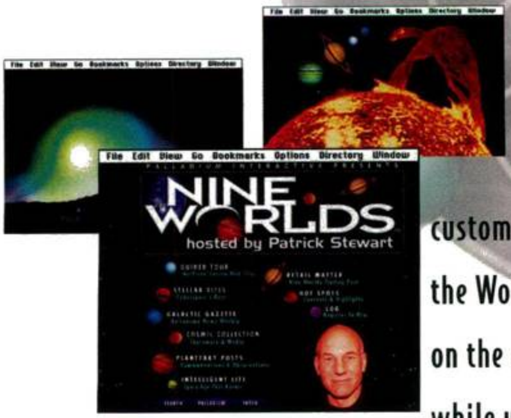
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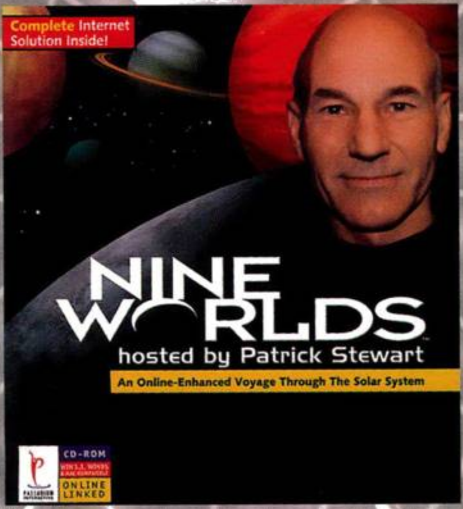
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# Planetarium Programs

| Program Name | Version | Developer | Price | Comp | System | CD-ROM | H. Drive | Mem | Display | # Stars | # Objects | Opt DB | Scope |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AstroSearch | | Meade Instruments | $99.95 | PC | Win | | yes | 640 KB | CGA | 45,000 stars and objects | | | Y |
| Big Blue Skies | | Andromeda Soft. | S | PC | DOS | | | | VGA | 1,500 | | 3,200 stars | |
| Dance of the Planets | 2.71 | ARC Sci. Sim. | $95 | PC (386) | DOS 5 | | 2MB | 640KB | VGA | 9,200 | 1,300 | yes | N |
| Dance of the Planets | Q.E.D. | ARC Sci. Sim. | $145 | PC (386) | DOS 5 | | 2MB | 640KB | VGA | 9,200 | 1,300 | yes | N |
| Deep Space | 5 | David Chandler | $129 | PC (386) | DOS 5 | X | 14MB | 2MB | VGA | 15 million | 20,000 | | opt. |
| Distant Suns | 2.0 | Virtual Reality | $34.95 | Mac | 6 or 7 | X | 2MB | 2MB | color | 15 million | 2,000 | | N |
| Distant Suns-First Light | 1.1 | Virtual Reality | $64.95 | PC (486) | Win 3.X | X | 8MB | 8MB | SVGA | 15 million | 2,000 | | N |
| Earth Centered Universe | 2.0B | Nova Astronomics | $50 | PC (386) | Win 3.1 | | 7MB | 4MB | VGA | 245,000 | 10,500 | yes | Y |
| Epoch 2000 sk | | Meade | $149 | PC | Win | | | | EGA | 259,000 | 13,000 | | Y |
| Epoch 2000 sk CD | | Meade | $179 | PC | Win | X | | | EGA | 15 million | 13,000 | | Y |
| Expert Astronomer | | Expert Software | $14.95 | PC | Win 3.X | X | | | VGA | 9,100 | 2,000 | | N |
| Guide | 5.0 | Project Pluto | $69 | PC | DOS/Win | X | 2MB | 640KB | VGA | 15 million | 100,000 | | Y |
| Hipparchus | 5.2 | sofTouch APpL. | $49.95 | Mac | 6.X | | | 1MB | | 9,100 | 110 | | N |
| HyperSky | | Willmann-Bell | $49.95 | PC | DOS | optional | 2.4MB | 500KB | CGA | 46,000 | 5,500 | yes | |
| HyperSky | | Willmann-Bell | $49.95 | PC | Win 3.1 | X | 2.4MB | 500KB | CGA | 46,000 | 5,500 | yes | |
| HyperSky | | Willmann-Bell | $99.90 | PC | DOS | X | 2.4MB | 500KB | CGA | 15 million | 80,000 | | |
| LodeStar | 2.1 | Zephyr Services | $89.95 | PC | DOS | | | | CGA | 9,000 | 110 | | |
| LodeStar Plus II | | Zephyr Services | $149.95 | PC | DOS | | no | | CGA | 9,100 | 7,840 | 260,000 stars | |
| LodeStar Pro | 1.02 | Zephyr Services | $259.95 | PC (286) | DOS | optional | 3MB | 2 MB | VGA | 9,100 | 110 | yes | |
| MacStronomy | 2.0.3 | Etlon Software | $60 | Mac | 6.0.4 or 7 | | 2MB | 2MB | color | 10,000 | 1,100 | yes | N |
| MegaStar | 3.0 | E.L.B. Software | $129 | PC (386) | Win 3.1 | X | 5MB | 4MB | VGA | 15 million | 110,000 | | N |
| NGP | 2.7 | Gary Williams | F | PC | DOS | | 6MB | 512KB | VGA | | 8,163 | | |
| NightSky | | Zephyr Services | $59.95 | PC | DOS | | | | CGA | 9,000 | | | |
| NightSky | | Zephyr Services | $79.95 | PC | DOS | | | | CGA | 50,000 | | | |
| Observer | 1.0 | Procyon Systems | $49.95 | Mac | 7 | | | 2.5MB | | 9,500 | | | N |
| Observer level I | 2.0 | Procyon Systems | $69.95 | Mac | 7 | | | 2.5MB | | 9,500 | 14,000 | | N |
| Observer level II | 2.0 | Procyon Systems | $69.95 | Mac | 7 | | 13.5MB | 2.5MB | | 259,000 | 40,000 | | N |
| Observer Deluxe | 2.0 | Procyon Systems | $299.95 | Mac | 7 | | | 2.5MB | | 259,000 | 40,000 | | Y |
| PC SKY | 1.1 | CapellaSoft | $99 | PC (286) | DOS | | 3.2MB | 640KB | VGA | 178,000 | 200 | | |
| Personal Observatory | | ISIS | $399 | PC | DOS | | | | VGA | | | | |
| PLAstro | | Zephyr Services | $99.95 | PC | DOS | | 2.5MB | | VGA | 9,100 | | | |
| Redshift | 2 | Maris Multimedia | $49.95 | Mac/PC | 7/Win | 2X | 1.5MB | 8MB | color | 250,000 | 40,000 | | N |
| Remote Observing | 1.0 | Software Bisque | $299 | PC | Win 3.1 | | yes | | VGA | | | | |
| Saguaro Database | 6.0 | Saguaro Astr. Club | $2 | | | | | | | | 10,000 | | |
| Sky Chart | 2.5 | So. Stars Software | | Mac | 7 | | 1MB | 2MB | color | 20,000 | 5,000 | | N |
| SkyGazer | | Carina Software | $79.95 | Mac | 6.0.5 | | 3MB | 1MB | | | | | |
| Sky Globe | 3.6 | KlassM Software | $20 | PC | DOS | | no | 640KB | CGA | 29,000 | 110 | yes | |
| SkyLights | | Zephyr Services | $89.95 | PC | Win 3.1 | | yes | | | 1,600 | 400 | | |
| Sky Pilot | | Carina Software | $50 | Mac | 6.0.7 | | | | runs with Voyager II | | | | |
| Sky Tools | 1.0 | CapellaSoft | $119 | PC (386) | Win 3.1 | X | 1MB | 4MB | VGA | 15 million | 80,000 | | |
| Starry Night | 1.03 | Slenna Software | $37 | Mac | 7 | | 3MB | 4MB | color | 65,000 | 10,000 | | N |
| StarScape | | Zephyr Services | $89.95 | PC | Win 3.1 | | yes | | | 9,000 | | | |
| Stars & Scopes | 3.4 | So. Stars Software | $49 | Mac | 7 | | 3MB | 2MB | color | 1,600 | 400 | | Y |
| Superstar | 4 | picoScience | $149.95 | PC | DOS | | 10MB | 640KB | VGA | 259,000 | 7,800 | yes | |
| Superstar Pro | 4 | picoScience | $249.95 | PC | DOS | | 10MB | 640KB | VGA | 259,000 | 7,800 | yes | |
| The Cosmos | 4.0 | Mensys | $79 | PC (386) | OS/2 | | 5MB | 1MB | VGA | 259,000 | 10,400 | yes | N |
| TheSky level II | 4 | Software Bisque | $129 | PC (386) | Win 3.X | optional | 5MB | 4MB | VGA | 46,000 | 8,700 | yes | Y |
| TheSky level III | 4 | Software Bisque | $199 | PC (386) | Win 3.X | optional | 18MB | 4MB | VGA | 259,000 | 21,000 | yes | Y |
| TheSky IV (GSC) | 4 | Software Bisque | $249 | PC (386) | Win 3.X | X | 3MB | 4MB | VGA | 15 million | 87,500 | | Y |
| Voyager II | 2.0 | Carina Software | $159.50 | Mac | 6.0.7 | optional | yes | 1.5MB | | 259,000 | 12,000 | yes | |

An "S" in the "Price" column indicates a shareware program; if you like the program and want to keep it, you pay the developer an amount specified in the program's documentation. An "F" indicates a freeware program; the developer provides this program to the community free. The CD-ROM column lists "2X" when the software requires a double-speed or faster CD-ROM drive. "Display" lists the minimum requirement. The program may support higher video modes. "Opt. DB" indicates whether optional databases are available to extend either the stellar or deep-sky databases. "Y" in the Scope column indicates that the program will control a telescope; check with the software developer to determine which scopes the program controls and whether special encoders are required.

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# Selected CD-ROMS

| Images | Distributed by | Price | Format | Description |
|---|---|---|---|---|
| Amazing Universe III | Hopkins Technology | $39.95 | PC (Win 3.1) | 500 images of planets and deep-sky objects |
| Apollo 17 Collection | Astronomical Research Network | $250 | ARN, BMP | 2 CD-ROMs full of images from the lunar mission |
| Comet Collision with Jupiter | Geppetto and Son | $19.95 | — | 300 images of Shoemaker-Levy 9 impact on Jupiter |
| Comet Halley, Int'l. Halley Watch | National Space Science Data Center | $260 | FITS, PDS and text | Halley Watch data on 26 disks |
| Comet Smash | Network Cybernetics | $39 | FITS, GIF, TIFF | 700 images of Shoemaker-Levy 9 impact on Jupiter |
| Cosmic Background Explorer | National Space Science Data Center | $43 |  | data from DMR experiment on 1 disk |
| Cosmic Background Explorer | National Space Science Data Center | $20 |  | data from DIRBE experiment on 2 disks |
| Einstein Observatory | National Space Science Data Center | $12 | FITS | High resolution images on 2 disks |
| Galileo Cruise Imaging | National Space Science Data Center | $84 | PDS and VICAR | Images from Galileo on 14 disks |
| HST Archive | Digital Entertainment | $19.99 | Mac/PC | Hubble Space Telescope images |
| IRAS Sky Survey Atlas (ISSA) | National Space Science Data Center | $66 | FITS | 12.5° x 12.5° images on 11 disks |
| Journey to the Planets | Multicom Publishing | $59.95 | Mac/PC | Fly-bys and images of planets |
| Jupiter Impact | Pacific HiTech | $29.95 | GIF, BMP, PICT | Comet Shoemaker-Levy 9 impact on Jupiter |
| Magellan Venus data | National Space Science Data Center | $450 |  | Radar mosaic images (FMAP) on 45 disks |
| Magellan Venus data | National Space Science Data Center | $1260 |  | Radar mosaic images (F-MIDR) on 126 disks |
| Mars and Venus CD | Nick Marella | $29.95 | BMP | 600 Viking and Magellan images |
| Mars Digital Image Map | National Space Science Data Center | $1404 | MDIM and GIF | Images of Mars on 14 disks |
| Mars: The Search Begins | WeMake CDs | $30 | Win | Movies — Viking missions, first to land on Mars |
| Mission to the Moon | National Space Science Data Center | $880 | PDS | Images of Moon by Clementine on 88 disks |
| Multimedia Space Explorer | Betacorp | — | PC (Win) | Images and movies from space shuttle, Hubble, more |
| New View of Space | WeMake CDs | $30 | Win | Movies — Various missions, from launch pad into space |
| RealSky | Astronomical Society of the Pacific | $250 | Mac/PC | Palomar Obs. Sky Survey on eight CD-ROMs |
| ROSAT: The Images | National Space Science Data Center | $60 |  | X-ray images from the Roentgen Satellite on 6 disks |
| Shuttle Encyclopedia | Walnut Creek CDROM | $39.95 | GIF, text | 3,000 images taken of and from space shuttles |
| Space | Seattle Support Group | $49.95 | BMP, JPEG, PICT | 200 images of planets and space |
| Space and Astronomy | Walnut Creek CDROM | $39.95 | GIF, text | 1,000 images of Earth, the planets, and space shuttles |
| Space Science Library | Astronomical Society of the Pacific | $99.95 | Mac | Electronic Picture Books with hundreds of images |
| Space View | Pacific HiTech | $29.95 | — | 500 images of planets with multilingual descriptions |
| Starlite | Astronomical Research Network | $49.95 | ARN | 1,000 images of planets, galaxies, and more |
| Stars and Beyond: Images of NASA | WeMake CDs | $30 | BMP, GIF, PCX | 375 images of the planets |
| Viking Orbiter images of Mars | National Space Science Data Center | $460 | PDS | Images on 46 disks |
| Visions of Saturn | WeMake CDs | $30 | GIF | Voyager images of the Ringed Planet |
| Voyage to the Planets | Astronomical Research Network | — | ARN | Set of 7 disks of the Moon and planets |
| Voyage to the Stars | Astronomical Research Network | — | ARN | Set of 5 disks of galaxies and nebulae |
| Voyager Moons | Nick Marella | $29.95 | BMP | 600 Voyager images of outer planets and their moons |
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| Principal Galaxy Catalogue | Observatorie de Lyon | $90 | text | Information about 73,000 galaxies |
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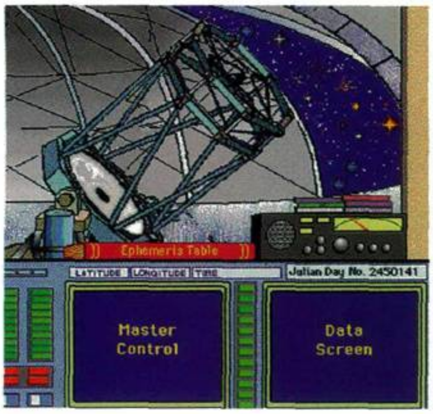
| Astronomical Explorations | E.M.M.E. Interactive | $27.99 | Mac/PC | Guide to the solar system and beyond |
| Astronomy Village | NASA CORE | $5 | Mac | Hands-on astronomy activities for 9th grade students |
| Astroware | Network Cybernetics | $39 | Mac/PC | Astronomy freeware and shareware programs |
| Explore the Planets | Tasa Graphic Arts | $59 | Mac/PC | Comparative tour of planets and geologic processes |
| Eyes to the Stars | Wolf 359 | $49.95 | PC | Guidebook to astroimaging plus 600 images |
| Galaxy Guide | Parallax MultiMedia | $49.95 | PC | Provides info on 38 constellations |
| Magic School Bus/Solar System | Microsoft | $49.95 | PC | For children ages 6 -10 |
| Night Sky Interactive | Beachware | $18.99 | Mac/PC | Introduction to astronomy |
| Nine Worlds | Palladium Interactive | $39.95 | Mac/PC | Voyage through the solar system |
| Space Rocks | Astronomical Research Network | $149.95 | BMP | Images and information about meteorites |
| The Planets | Byron Preiss | $54.95 | Mac/PC | Virtual museum about the planets |
| Ultimate Einstein | Digital Bauhaus | $49.95 | PC or Mac | Trace Einstein's life and scientific career |
| View from Earth | Warner New Media | $79.98 | PC | Describes Earth, Sun, and Moon with text and images |
| Visions of Mars | Virtual Reality | $34.95 | Mac/PC | Collection of literature and art about Mars |
| Voyage through the Solar System | Palo/Haklar | $49.95 | Mac/PC | Describes all the planets using text, movies, and mages |
| Voyage to the Outer Planets | NRSPACE Software | $49.95 | Win | Tours Jupiter, Saturn, Uranus, Neptune, and their moons |

NOTE: Some prices reflect "street prices" available from some mail order companies. Format indicates image file formats used or operating system needed to view the disks.

processing software. Special-purpose programs can trace light passing through the optics of a telescope, show how stars age, display views of Mars as seen from its surface, plot the orbits of binary stars, and simulate a collision between two galaxies. A list of this software may be found in *Observer's Guide 1996*. □



**Enjoy learning astronomy with a multimedia program such as *The Astronomy Village* (Macintosh), which simulates how real astronomical research is done.**

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For convenience, many multimedia CD-ROMs contain software for both Macintosh and PC computers. CD-ROMs containing images often provide viewing programs, but users can also open the image files with many image-processing programs.

In the last several years, CD-ROM drives have become increasingly popular options for home computer buyers. Some multimedia packages now require double-speed (2X) or quadruple-speed (4X) drives. Check the package when purchasing CD-ROMs to be sure your CD-ROM can meet or exceed the speed rating.

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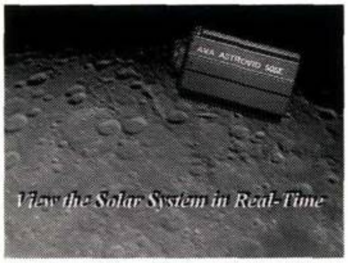

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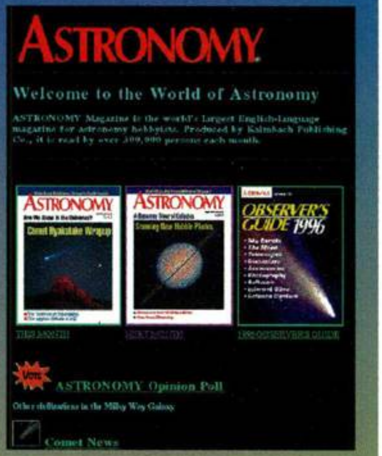
The Internet is a marvelous network of computers that connect people throughout the world to one another. America OnLine, CompuServe, or other online service members offer a connection to the Internet. Local service providers in most cities also provide inexpensive service to the Net.

Most people think of e-mail when they hear Internet, but it also provides the basis for the World Wide Web. The Web permits tying documents (text and image files) to each other using links embedded in the document. Users view the documents using a browser. To jump to the next document (which can be on an entirely different computer elsewhere in the world), they click on the highlighted text marking the link. (For more information, see "Blasting Along the Infobahn" in the June 1995 ASTRONOMY.)

Here's a collection of popular astronomy Web sites to get you started browsing the Web.



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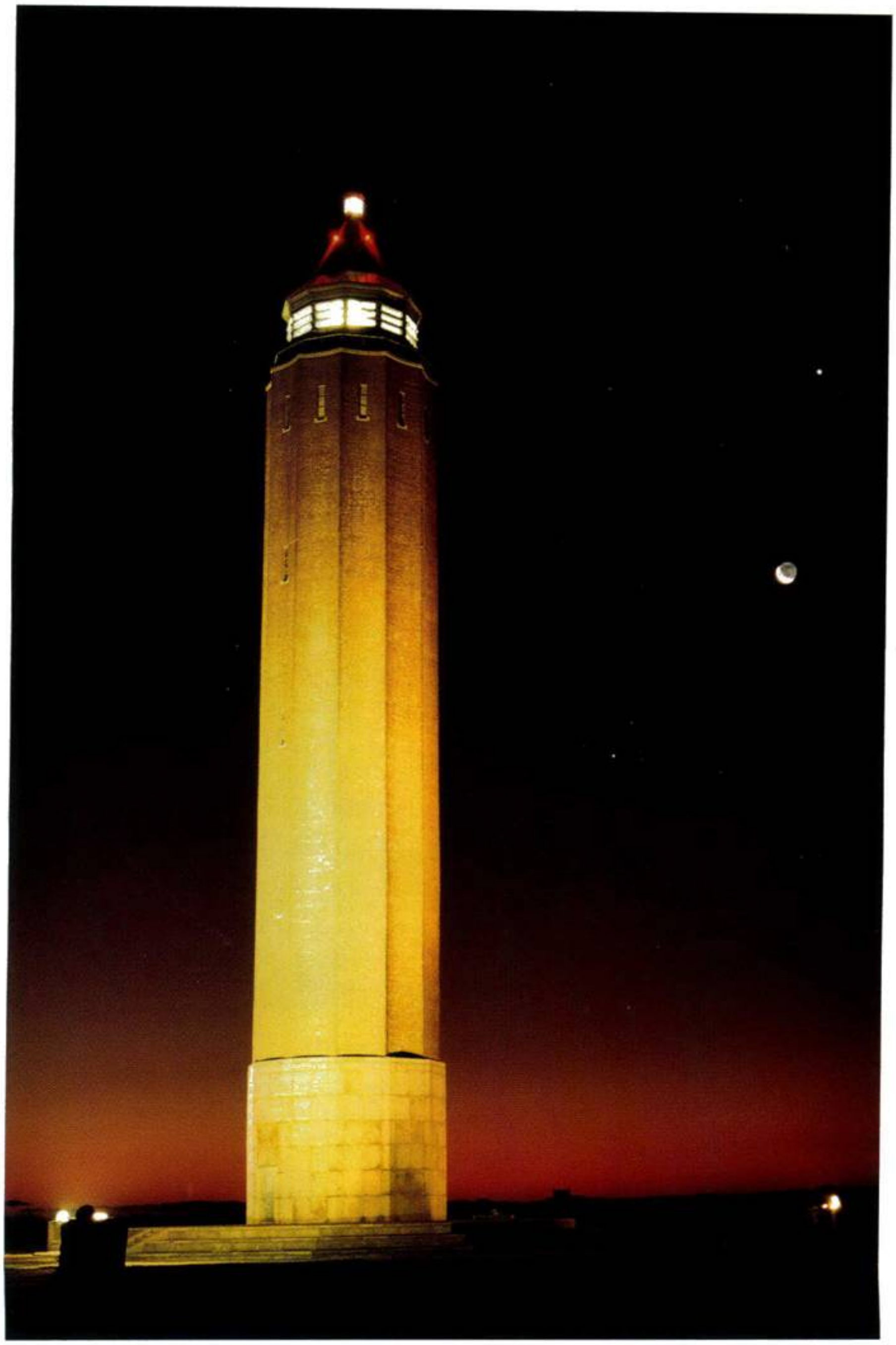
# CAPTURE THE SKY ON FILM

by Alan Dyer



**Conjunction between Venus, Jupiter, and the Moon**
*Larry Landolfi*
(35mm lens at f/2.8, Fujichrome 400, 15 seconds)

Astrophotography is seductive. Images of glowing, colorful nebulae fill the pages of books and magazines. "I want to take pictures just like that through my telescope," announce many first-time telescope buyers. Attracted by the alluring photos, some buyers shell out thousands of dollars on all the right equipment — elaborate telescopes, guiders, hypering kits, CCDs, arrays of lenses, and seemingly endless sets of adapters.

And yet, despite caseloads of gear, so many would-be astrophotographers end up with little to show for their effort and expense except fuzzy photos of trailed stars.

What went wrong? In a sentence, the enthusiasts dove into the deep-end of astrophotography before they learned to swim in the shallow end of easy and rewarding techniques. It is possible to take great images of the night sky the first time out and do it simply and cheaply. Here are twelve time-honored tips for success in astrophotography, and a few time-worn myths dispelled in the process.

## Tip 1: Keep it Simple

Some of the most striking images of the night sky are taken by photographers using no more than a camera fastened to a tripod. No telescopes, no tracking, no guiding, no focusing aids, no computer enhancement. Just the camera equipment you likely already own.

But surely images of the night sky require long time exposures, you might ask. Yes, some do. But today's fast films can record the Milky Way and more stars than you can see with the unaided eye in untracked exposures of only 30 seconds.

Try it one night. Load your camera with a fast ISO 800 to 3200 film and set the aperture at f/2 to f/2.8. Aim the camera at a starry region of the sky (the summer Milky Way is ideal), then open the shutter for a series of exposures from 10 to 40 seconds. You'll pick up loads of stars. How good the photos turn out will depend largely on how dark your sky was. The darker the better.

While photos of starfields are what

most people have in mind when they think "astrophotography," other sky sights also make stunning targets for a well-aimed camera fixed to a tripod. Aurorae, meteors, close conjunctions of planets and the Moon, eclipses of the Sun and Moon, haloes around the Sun or Moon, even bright comets — all are well-suited for no-frills astrophotography. Take a look at the pictures throughout this section for recommended films and exposure times.

## Tip 2: Choose the Right Film

No one film is best for astrophotography. After all, sky subjects can range from as bright as the Sun to as faint as a remote galaxy. When selecting a film, the unavoidable tradeoff is between film grain and exposure time. A fast ISO 800 film can record a sky scene with ⅛th the exposure time of a slower ISO 100 film or, conversely, grab many more stars in the same exposure time.

But the faster the film, the grainier it is. A good rule-of-thumb is to use as slow a film as your subject will allow. Bright subjects such as the Sun, Moon, and wide-angle twilight scenes are best on slow ISO 50 to 100 films. But shoot faint subjects such as aurorae or starfields on that speed film and you'll get dim, underexposed frames.

Most nocturnal subjects need at least ISO 400 films. Today's ISO 800 to 1000 films are so good they can be considered standard films of choice. I find that print films such as Fuji's Super G 800 or Kodak's Royal Gold 1000 seem to pick up more stars in a given exposure time than equivalent-speed slide films such as Fuji's Provia 1600 or Kodak's Ektachrome P1600. But among the fast slide films, tests show that Ektachrome P1600 is the champ for images of starfields and nebulosity. (See "Life in the Fast Lane," May 1995 ASTRONOMY.)

## Tip 3: Choose the Right Camera

Any camera with a shutter that can be locked open for time exposures is suitable for night sky photography. But the interchangeable lenses of 35mm single-lens-reflex cameras make these the prime choices. One type of 35mm SLR stands out as the best of the lot, and it isn't the newest programmable model. Just the opposite — astrophotographers universally prefer old-fashioned manual-focus, manual-exposure cameras.

**Milky Way and Moonlit Cliffs**
*Jerry Schad*
(24mm lens at f/1.4, Kodak P1600 silde film pushed to 3200, 1-minute exposure)

You may discover why on your first night out with an all-electronic camera, especially if the night is cold. During exposures of several minutes, the batteries in these cameras can lose power, causing the shutter to close prematurely or to lock open out of control. Your state-of-the-art camera becomes dead weight.

A select few models won't suffer this fate. These include the Canon F1, Contax S2, Nikon FM2 and F3, Olympus OM-4T, and Pentax K1000 and LX. Their selling point is a mechanical Bulb — or time exposure — shutter setting that works regardless of battery power. Some also have optional focusing screens and finders better suited for dim-light photography. (See "Choosing a Camera for Astrophotography," March 1996 ASTRONOMY.)

As an alternative to new models, astrophotographers routinely prowl used camera shops hunting for older but reliable pre-electronic cameras. The Olympus OM-1 and Nikon F and F2 are classic cameras for sky shooting.

## Tip 4: Keep it Fast; Keep it Short

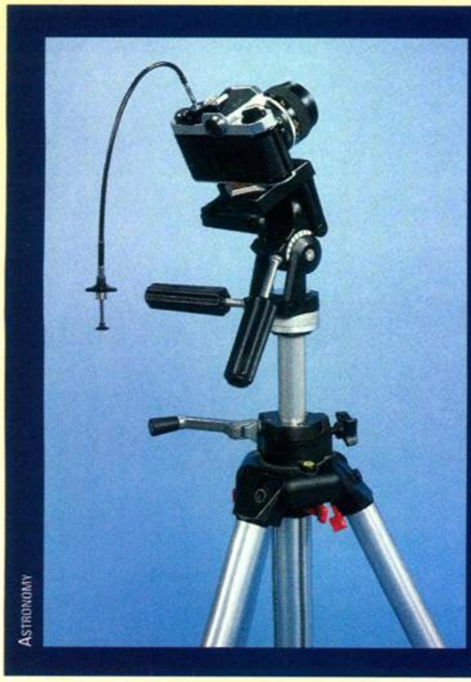
The right camera and film seem obvious prerequisites for good astrophotos. But the next choice many enthusiasts make is often the worst — they buy the biggest telescope they can thinking that'll net them the best photos. Oops!

The problem is twofold. First, big telescopes usually have big focal lengths, perhaps 2,000 to 3,000mm. Yes, the tremendous focal length makes the object appear large on the film. But magnified just as large will be every minor tracking error in the telescope's drive system. The trailed stars that result come as quite a shock.

Simply opening a shutter and letting a clock drive freewheel by itself won't work, not at these focal lengths. The magic number is about 200mm. If you are shooting deep-sky targets with any focal length longer than that, be it lens or telescope, you will have to guide. The longer the focal length, the more accurate the guiding must be.

The main cause of wiggly stars is the slight speed variations all telescope drives exhibit. To correct the wanderings, astrophotographers use off-axis guiders (popular with Schmidt-Cassegrain telescopes) or separate guidescopes (popular with Newtonian and refractor telescopes). Both allow monitoring the movement of a nearby guidestar while shooting through the main telescope. A guiding eyepiece with illuminated crosshairs is essential. If the star wanders off, you hit a speed control button to jockey it back into position. (See "Beating Back the Guiding Gremlins," September 1994 ASTRONOMY.)

# Tripod and Camera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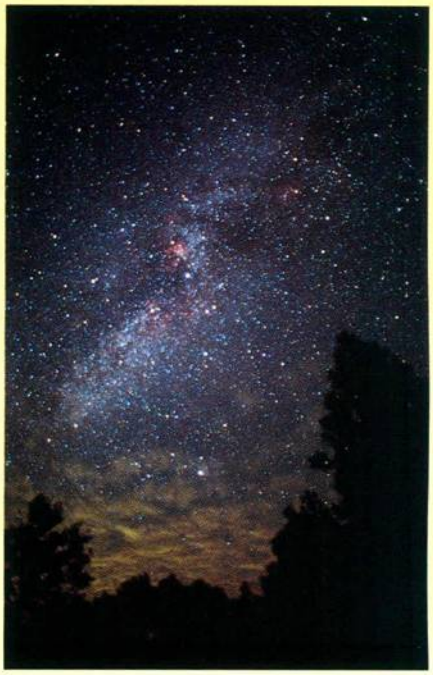
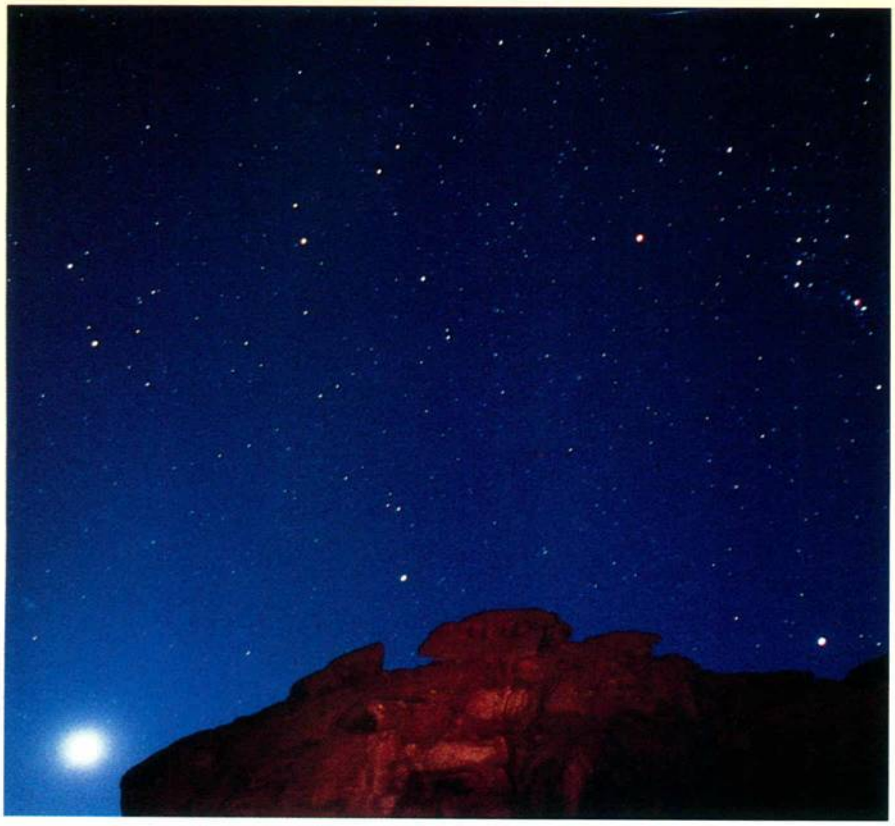
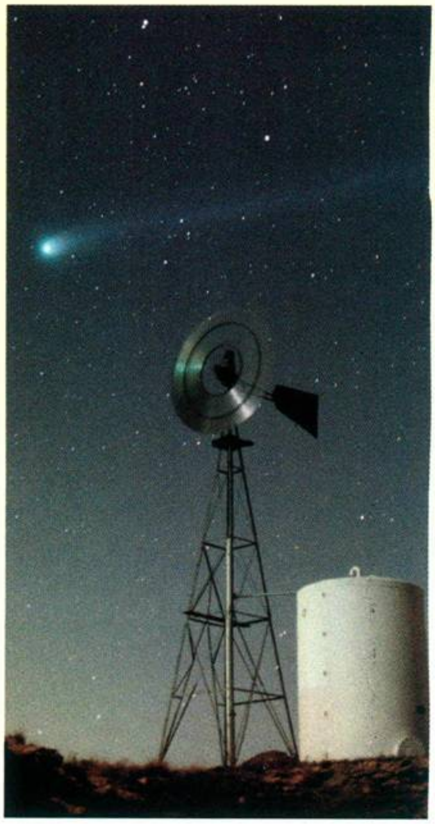
**Astrophotography is as simple as putting a camera on a tripod. All you need is a 50mm lens, a cable release, a camera with a bulb setting, and some film faster than ISO 400. Because astrophoto targets lie out in space, don't forget to focus on infinity. Take a glance through the pictures or consult the astrophotography starting points sidebar for target ideas.**



**Star Clouds and Earthly Clouds**
*Jerry Schad*
(24mm lens at f/1.7, Kodak P1600 slide film pushed to ISO 3200, 1-minute exposure)



**Orion, Gemini Rise with the Moon**
*Jerry Schad*
(24mm lens at f/1.7, Kodak P1600 slide film pushed to 3200, 1-minute exposure)



**Hyakutake Over El Rancho Homer, Texas**
*Gary L. Meador*
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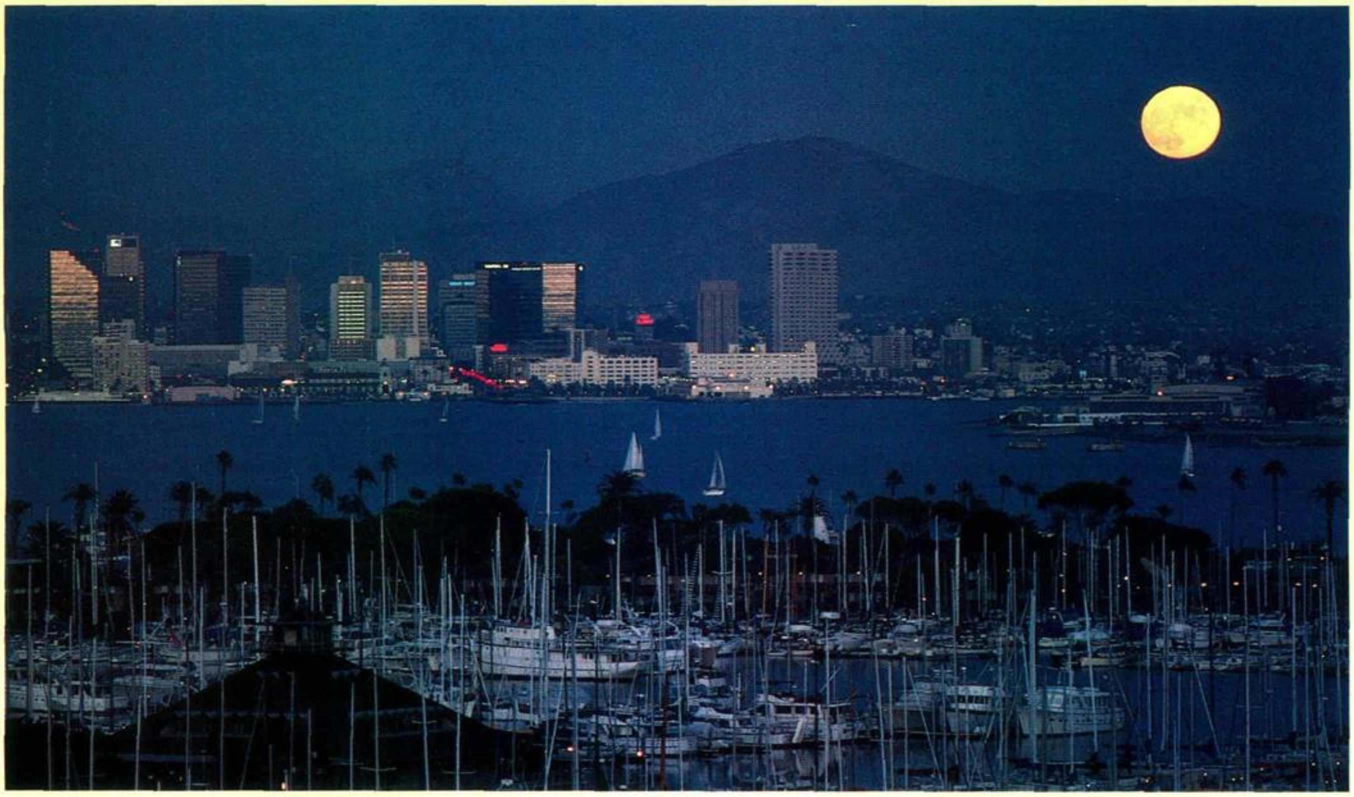
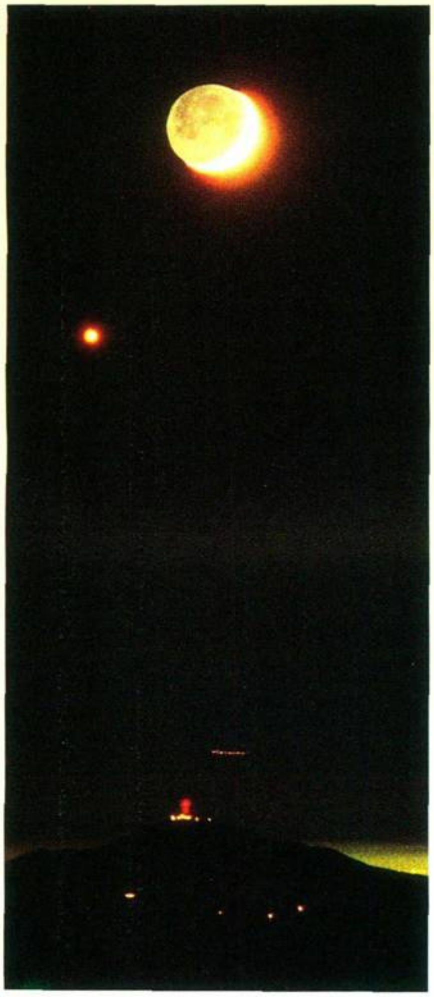




**Moon and Venus Above Cityscape**

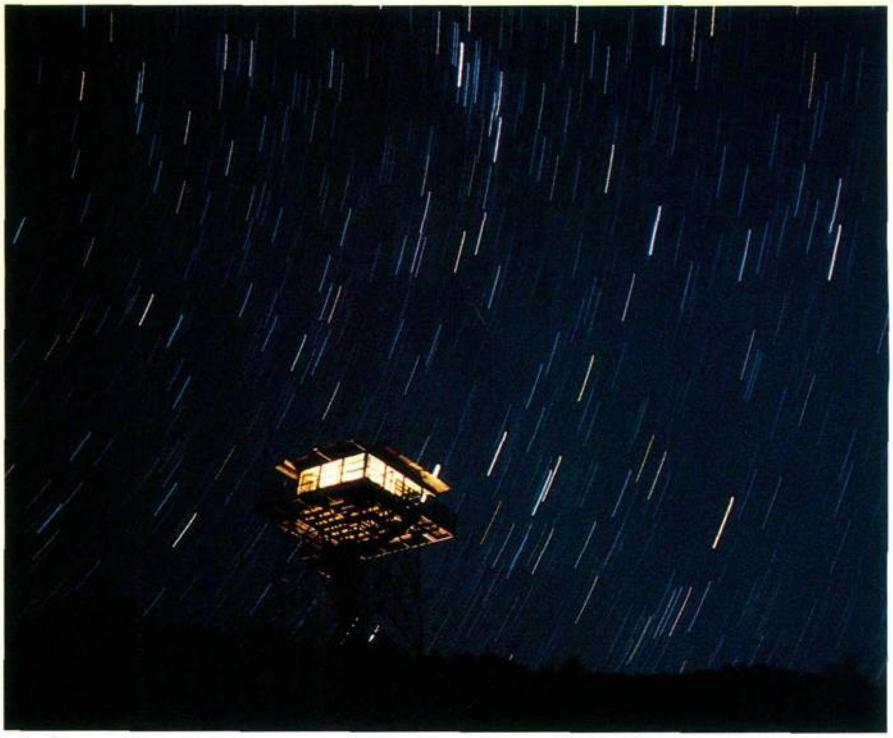
*Jerry Schad*

(200mm lens at f/2.8, Kodak P1600 slide film pushed to 3200, 4-second exposure)

**Moonrise In San Diego**

*Jerry Schad*

(200mm lens at f/5.6, Kodak P1600 slide film pushed to 3200, 5-second exposure)

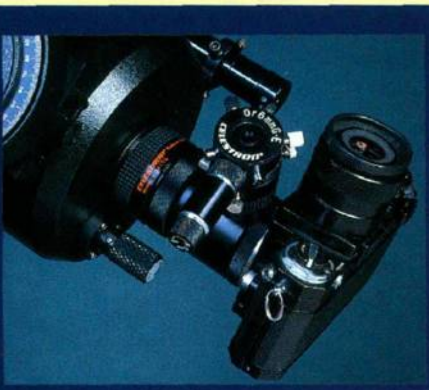


**Meteor Over a Fire Tower**

*Jerry Schad*

(35mm lens at f/2, Kodak P1600 slide film, 15 minutes.)

# Astrophotography with a Telescope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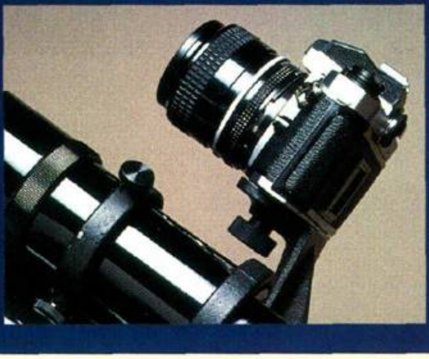
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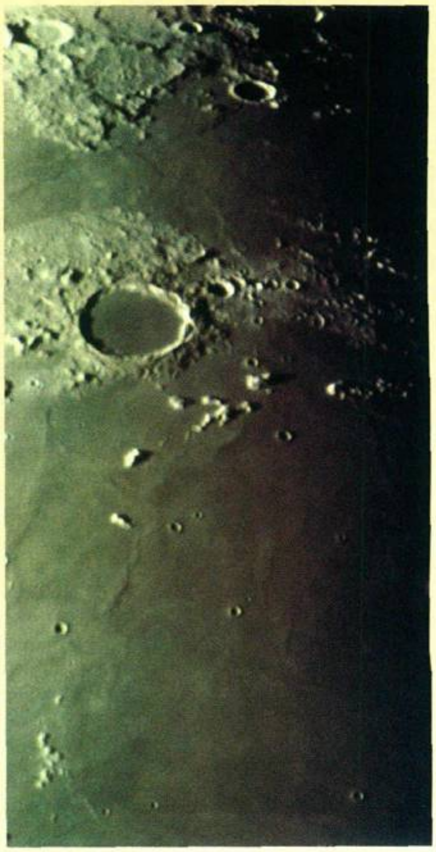
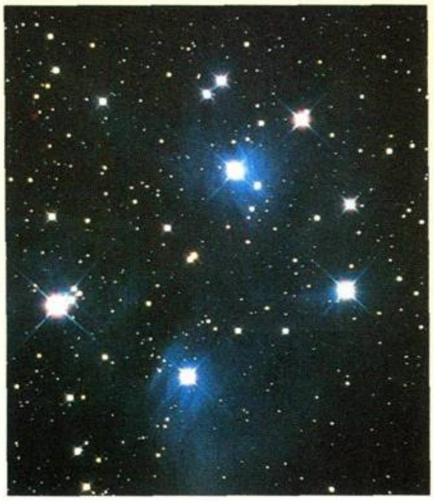
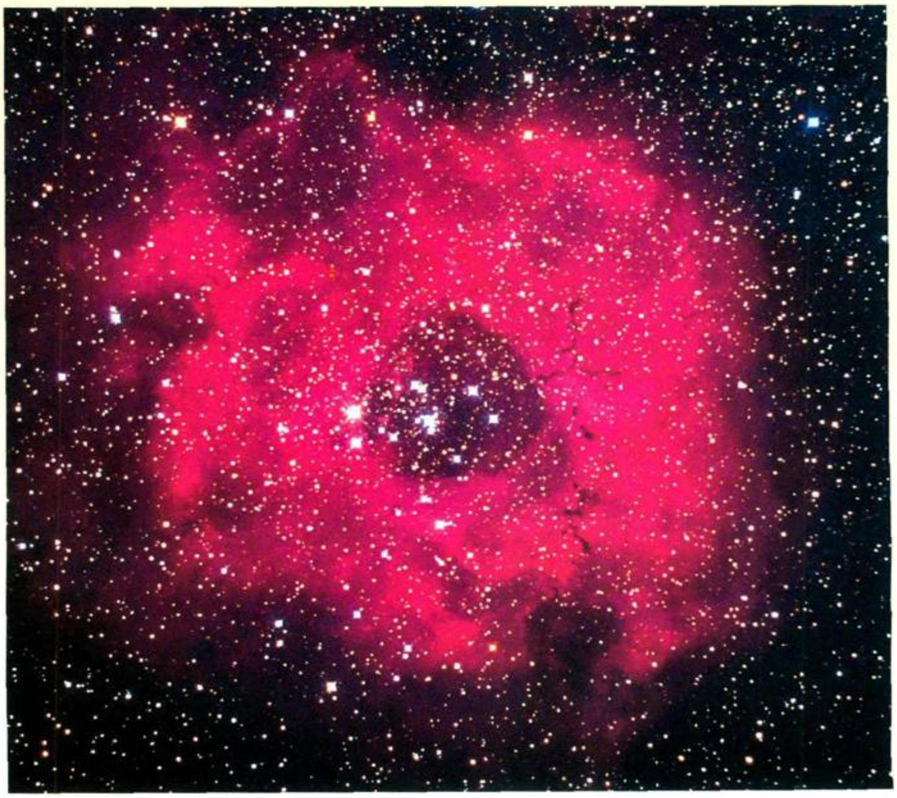
A telescope can work as giant telephoto lens, using prime focus and eyepiece projection techniques. A T-ring that matches your brand of camera lets you hook it directly to the telescope (left, top). Pictures several minutes long require other accessories like an equatorial mount, clock drive, a guidescope, and/or guider. Ride a camera on top of the scope for long-exposure, piggyback astrophotography (left, bottom).

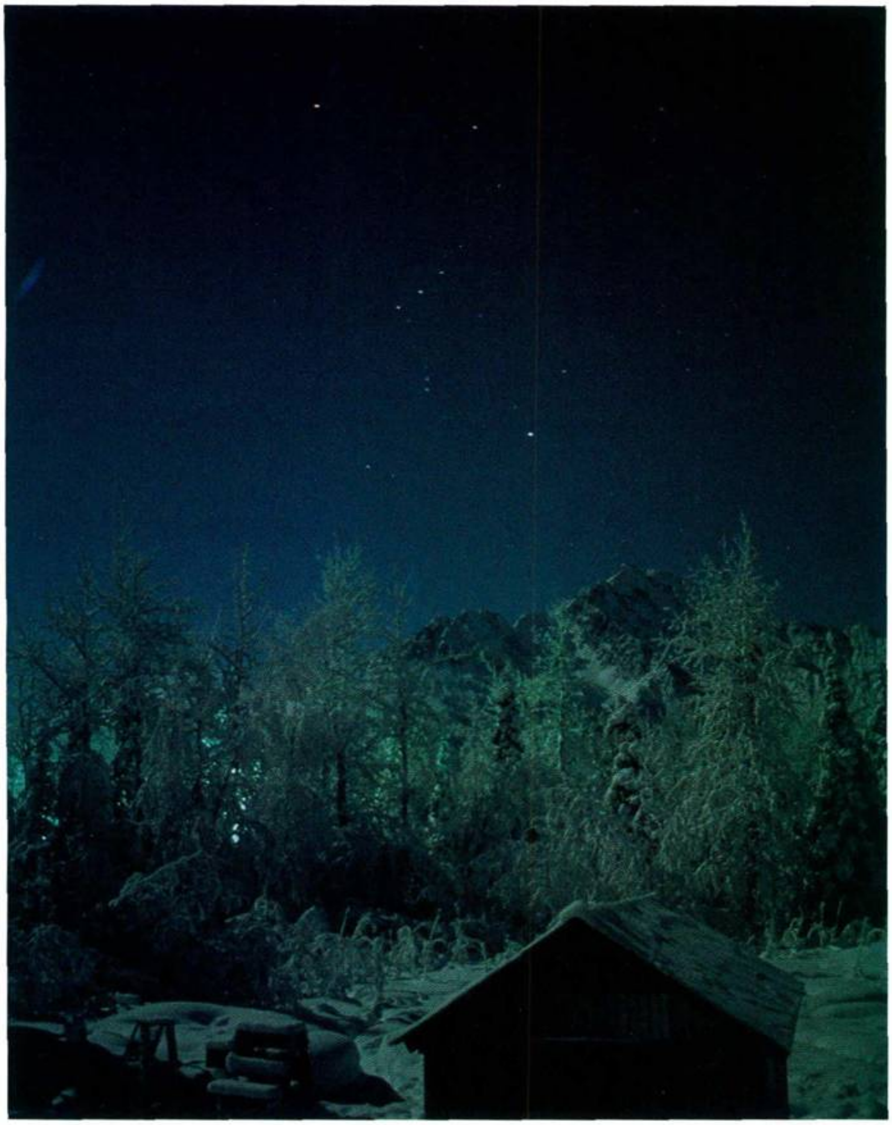

**Plato and Mare Imbrium**
*Jean Dragesco*
(14-inch f/10 SCT, Ektachrome 200, ½-second exposure)


**Dust Clouds in M45**
*Lee C. Coombs*
(10-inch f/5 reflector, P1600 slide film, 30-minute exposure)


**The Rosette Nebula's Red Glow**
*Michael Stecker*
(8-inch f/4 reflector, Fujicolor HG 400 film, composite of two 45-minute exposures)

**M42, the Orion Nebula**
*Dennis Staffne*
(5.2-inch f/4.5 scope, hypersensitized Provira 100 film pushed to ISO 200, 30-minute exposure)

**Fisheye of the Winter Milky Way**
*Douglas C. Zubenel*
(16mm f/2.8 lens, Fuji Super G 400 film, 20-minute exposure)



**Orion in a Wintery Scene**

*Jim Lager*

(35mm lens at f/2.8, Ektachrome 400, 1-minute exposure)

Now we hit the the second drawback of big scopes. They often have slow f/ratios of f/8 to f/15. To record deep-sky objects at such f/ratios requires grueling exposures of one to two hours, all the time guiding with excruciating accuracy. It's torture. And too often shots still come back trailed! Sure, there are several CCD autoguiders on the market that can make all the corrections automatically, but expect to spend $400 to $900 for the additional complexity. Remember the caseloads of gear?

Here's some advice: If it's closeups of colorful nebulae you're after, go fast and go short. Use fast f/ratio (f/4 to f/6) telescopes with short focal lengths (400 to 1200mm). A fast, solidly-mounted 4-inch telescope is ideal. The benefits are twofold: exposures are a manageable 10 to 30 minutes and the tolerance for mistracking, which always creeps in to some degree, is far greater. Both multiply your chances of grabbing that perfect portrait of the Orion Nebula.

## Tip 5: Go Faster

An easier way to successful images of stars and nebulae is to not even bother with a telescope. It sounds too good to be true but it works. The secret is to piggyback a camera equipped with a good, fast lens (a 135mm f/2.8 telephoto will do nicely) onto a telescope. Many manufacturers offer "piggyback" brackets for just this purpose. The telescope needs to be equipped with an equatorial mount and clock drive to follow the stars automatically.

The Orion Nebula, the Horsehead, the Rosette, the North America, the Andromeda Galaxy — these and many more targets are ideal for a telephoto lens. Some of the finest images of Comet Hyakutake were taken by photographers with just this technique. The same will be true of Comet Hale-Bopp.

In fact, for most piggyback photography a telescope is unnecessary. All you really need is the equatorial mount and accurate motor drive. Provided the mount is well polar aligned (a big proviso) and you use lenses no longer than 135mm and exposures no longer than 10 to 15 minutes, guiding shouldn't be required. You can actually let the drive run, open the shutter, and walk away.

Amazingly, you can even dispense with the full-blown equatorial mount. Easy-to-build tracking devices (see "Build an Astrophoto Platform," November 1992 ASTRONOMY) and low-cost commercial trackers that mount on any sturdy tripod can carry a camera across the sky accurately enough for 15-minute exposures. With an f/2.8 lens and ISO 800 film, this is long enough to reach the limits of the darkest sky. It's all simple, satisfying, and successful.

## Tip 6: Find a Dark Sky

First attempts at long exposures of the night sky are often bleached by bright skies, or discolored by the ugly glow of green or yellow streetlights. The answer here is not special films or filters. Equipment alone can't provide dark skies, only distance can. For the best deep-sky images, drive as far from interfering city lights as you can. Only the Moon and planets are relatively unaffected by urban waste lighting.

## Tip 7: Don't Hyper . . . Yet

Despite dark skies and hour-long exposures, the film looks blank! Nothing shows up. Some photographers then immediately buy a film hypering kit, thinking once again that more equipment is the answer.

True, many of the images you see each month in ASTRONOMY have been taken on hypered film. This is film that has been "soaked" in a heated chamber pumped with a dry nitrogen-hydrogen gas (see "Hypercharge Your Astrofilm," April 1996 ASTRONOMY). Hypering effectively speeds up

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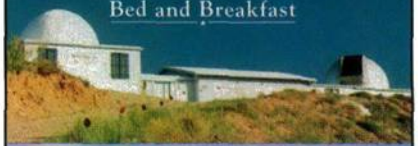

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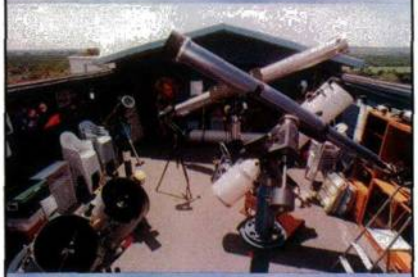

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a film and allows photographers to use a slower, finer-grained emulsion than would otherwise be possible with reasonable exposure times. Hypering is essential when shooting Kodak's black-and-white film, Tech Pan 2415. This wonder film produces the sharpest, most contrasty astro-images of any film on the market. But it must be hypered or it records blank sky.

But for the beginning shooter, hypering color film might be unnecessary and, if done incorrectly, introduce more confounding problems than it solves.

Instead of hypering, use longer exposures, or switch to a faster film. Films such as Fuji's Super G 800 or Kodak's P1600 slide film straight out of the box do a fantastic job recording deep-sky objects, and with finer grain than most 400-speed films of even 5 years ago. At f/4.5, Super G 800 will reach the sky fog limit of a dark site in an hour, with most deep-sky objects recording well in exposures far less than that.

For deep-sky shots through f/8 or slower telescopes, consider Konica 3200. Purists will balk at its graininess, but unless you intend to make poster-size blowups, this remarkable film will produce results more than adequate to satisfy aspiring photographers, often the first night out.

## Tip 8: Forget Galaxies

Galaxies are beautiful. Galaxies are inspiring. Galaxies are just too darn difficult to shoot! They're small, faint, and require lots of focal length and long exposures, which in turn require ultra-massive mounts, hypering, autoguiding . . . an escalating treadmill of technical hurdles. The latest technology amateur astronomers apply to galaxies is electronic CCD cameras, often with stunning results. But the technical investment can be immense.

# Advertiser Index

Adirondack Video Astronomy .......... 81
Amatuer Und Prazisionsoptik .......... 11
American Outdoors .......... 15
Andromeda Software, Inc .......... 81
Astro Photo .......... 93
Astronomical Adventures .......... 93
Astronomics .......... 21
Astronomy Shoppe .......... 96
ATM Journal .......... 9
Ball Photo Supply .......... 97
Berger Brothers Camera Exchange .......... 96
Bethany Sciences .......... 23
Blue Sky Pages .......... 96, 97
Bruce Johnston Computing .......... 83
Camera Bug .......... 96
Capellasoft .......... 83
CC Sales/Camera Corner, Inc .......... 97
Cobblestone Publishing, Inc .......... 13
Coulter Optical .......... 23
Day Star .......... 9
Eagle Optics .......... 97
EfstonScience Inc .......... 97
ELB Software .......... 76
Equatorial Platforms .......... 38
Evaporated Metal Films .......... 34
FC Meichsner Company .......... 25
Firefly Books .......... 3
Focus Camera .......... 91
Fujinon .......... 9
Helmer Publishing Inc. .......... 93
Hobby Corner, The .......... 96
International Optics Ltd .......... 13
JMB Inc .......... 33
K.C. Woodsmith .......... 21
Kalmbach Publishing Co. .. 19, 29, 39, 48, 81
Khan Scope Centre .......... 97
Knollwood Books .......... 34
La Maison de L'Astronomie .......... 33
Learning Technologies, Inc .......... 21, 38
Lumicon .......... 35
Mag One Instrument .......... 38
Makewood Products .......... 33
Meade Instruments Corporation .......... 108
New England Meteoritical .......... 33
Newport Glass Works .......... 23, 34
Night Skies .......... 96
Nurnberg Scientific .......... 97
Oceanside Photo & Telescope .......... 96
Optical Guidance Systems .......... 97
Orion Telescope Center .......... 107
Otis Observatory .......... 39
Palladium Interactive .......... 77
Perceptor .......... 97
Photo Supply, Inc .......... 96
Pocono Mountain Optics .......... 31
Procyon Systems .......... 83
Rivers Camera Shop .......... 96
Sarasota Camera Exchange .......... 7, 96
Sky Watchers Inn .......... 91
Sovietski collection .......... 29
Starsplitter Telescopes .......... 37
Stellar Vision .......... 96
Surplus Shack .......... 39
Swift Instruments .......... 13
Tech 2000 .......... 39
Technical Innovations .......... 33
Tele Vue Optics, Inc .......... 2
Thousand Oaks Optical .......... 17
Tropical Adventures .......... 93
Unitron, Inc .......... 15
Vernonscope .......... 25
Virgo Astronomics .......... 23
Virtual Reality .......... 79
Wolf 359 .......... 76
Wonder Works .......... 97

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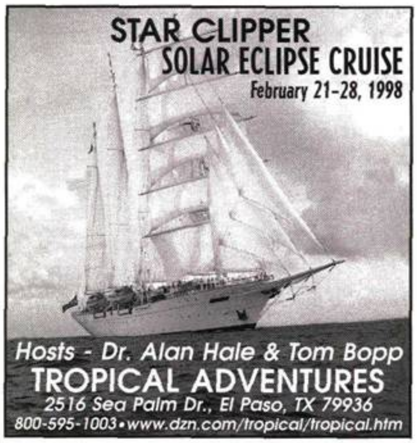

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# Astrophotography Starting Places

When shooting nightscapes, success comes not from how much equipment you own, but from paying attention to "photo opportunities" in the night sky and to creative composition. Here are tips for shooting sky subjects with nothing fancier than a camera on a tripod.

**Twilight Scenes and Conjunctions.** The Moon near Venus, or meetings of two more more planets in the dawn or dusk, are striking sights. Try using a light meter to get a reading off the twilight sky. But usually an exposure between ½- to 4 seconds at f/2.8 on ISO 50 to 100 film will do nicely.

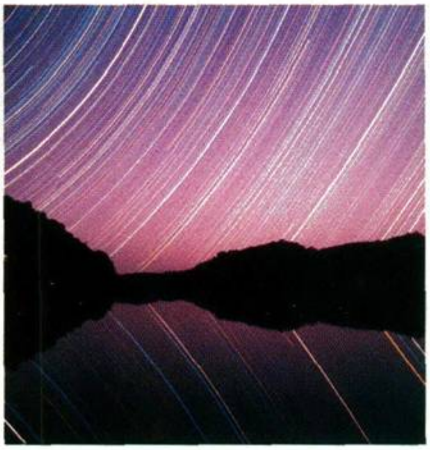
George Livadras

**Crescent Moon and Venus**

**Constellation Portraits.** Use ISO 400 to 3200 film, and a 28, 35, or 50mm lens at f/2.8. To keep stars looking like pinpoints exposures should be less than 20 to 40 seconds (longer exposures are okay only when shooting with a wide-angle lens toward the celestial poles).

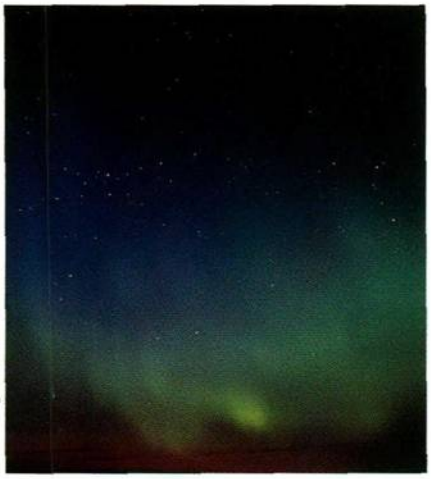
Stephen Walther

**Orion Shot in 30 Seconds**


Jerry Schad

**Star trails on a Lake of Glass**

**Star Trails.** Keep the shutter open for 5 minutes to 5 hours (but only if the sky is dark). A slower ISO 100 to 200 film at f/4 will be fine. For all-night exposures, stop the lens down to f/11 to avoid fogging the film. The longer the exposure, the longer the trail.


Alister Ling

**Aurora, Hyakutake Over Alberta**

**Aurorae.** Bright displays of Northern Lights require ISO 400 or faster film and apertures of f/2.8 or wider. Exposure times depend on the brightness of the aurora, but 5 to 60 seconds is usual — take lots of frames! A wide-angle lens is best. For a unique shot try a fisheye lens.

**Meteors.** You capture these only by accident. During a meteor shower such as the Perseids on August 11/12, take lots of star trail frames or short constellation portraits. With luck you'll also record a streaking meteor. But it has to be very bright to show up, even on fast film.

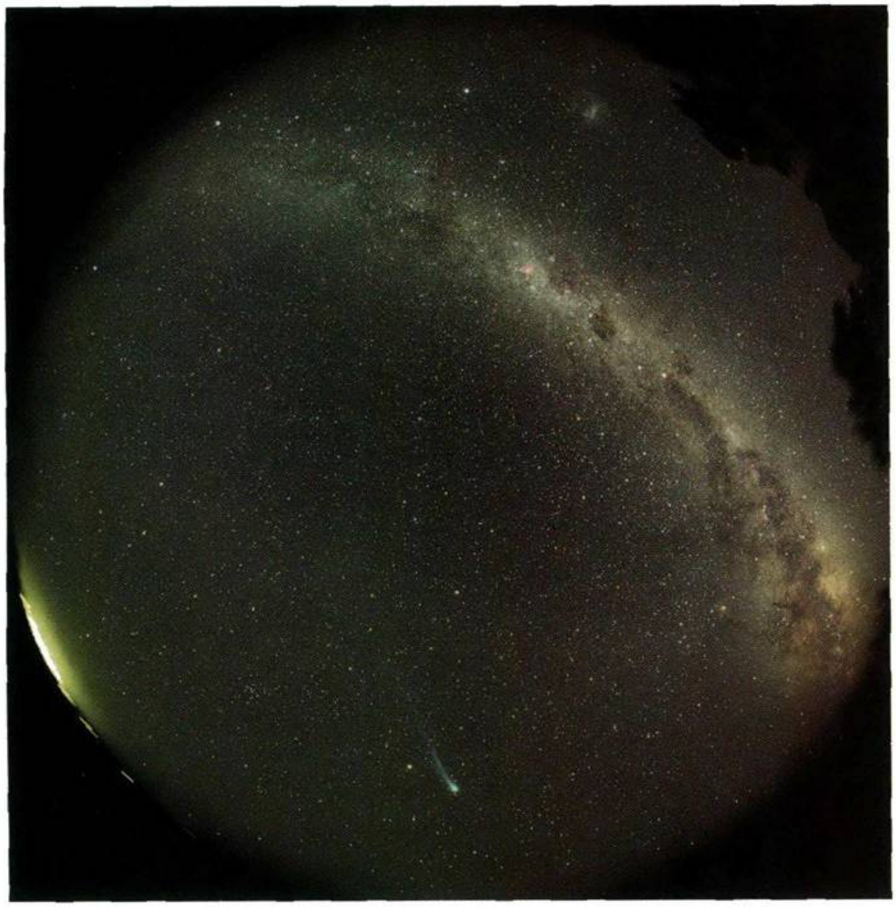
Mohammed Reza Zanran Lani

**A Perseid Meteor's Last Moment**

**Bright Comets.** A tracked camera is ideal, but a fixed camera with ISO 800 to 3200 film and exposures of 30 seconds to two minutes will pick up a bright naked-eye comet (like Hale-Bopp will be?). Don't worry about the trailing. It's better to have a trailed souvenir photo than no photo at all. So shoot away!

Dennis Anderson

**Comet West, 1976**



**Hyakutake Over Australia**
*Gordon Garradd*
(16mm lens at f/3.5, Fujicolor Super HGV 400, 15-minute exposure)

No, if you want fine deep-sky photos with a minimum of fuss, stick with "wide-angle" images of starfields and nebulosity taken with piggybacked cameras or with fast, short-focal-length telescopes.

## Tip 9: Put off Planets, Shoot the Moon

Other tough targets best to put off until later are the planets. Planets require shooting at effective focal lengths of 10,000mm or more (achieved through eyepiece projection adapters).

But the demands of fine focus and total lack of vibration during multi-second exposures at these focal lengths are unforgiving. What's more, the poor seeing (the term for atmospheric turbulence) prevalent at many observing sites will turn planet portraits into photos of featureless blobs. This is an area where electronic CCD cameras produce images far superior to all film results.

However, one solar system world makes for wonderful photos — the Moon. It's photogenic through any telescope, big or small. Exposures with ISO 400 film can be as short as 1/1000-second, quick enough that good lunar portraits are possible even with telescopes lacking an equatorial mount and clock drive. If you want some "wow" shots through your telescope, buy a basic camera adapter and shoot the Moon.

## Tip 10: Learn to Polar Align

The Moon (and the Sun with a safe solar filter) is, however, the only celestial object that can be shot through a non-equatorial telescope. All other photography with a telescope, and all piggyback shots, require a clock-driven equatorial mount.

For that type of mount to track the sky accurately, it must be aligned to the Celestial Pole, north or south depending on your hemisphere.

This is an intimidating chore for many beginners. But it's a necessary step. When all else fails, consult your telescope manual for instructions. Some German equatorial mounts have handy polar alignment sighting scopes that provide dead-accurate alignment in minutes. Finderscopes with polar alignment reticles are also a helpful addition.

## Tip 11: Learn the Sky

How will you photograph the Ring Nebula if you can't find it? How will you know what to photograph if you're not sure what a Messier object is? As with any form of nature photography, getting great shots requires getting to know your subject. Use the constellation charts elsewhere in this guide to master the lay of the sky.

If you're just getting into astronomy and are still sorting out the Messiers from the NGCs, don't even think about advanced deep-sky photography. Stick with simple camera-on-tripod shots of nightscapes and constellations.

## Tip 12: Practice, Practice, Practice

By staying with simple techniques, it's possible to get award-winning shots your first nights out. But no matter what your techniques or equipment, greater success comes with greater experience. Shoot the sky every chance you get. Use a wide range of exposure times.

Takes notes of your photo data for every frame, then compare them to your results. What exposure worked best? What film? What sky condition? It's the only way to learn and you never stop learning. Don't be intimidated by experts.

A final word of advice: Don't believe anyone who tells you the simple techniques are just "beginner's stuff." Some photographers earn a substantial income each year selling nothing but these types of simple astrophotos.

The creative possibilities in just nightscape photography alone are endless. By gently wading into astrophotography you'll be rewarded with encouraging results instead of drowning in rolls of discouraging failures. □

---

*Alan Dyer writes and produces science programs at the Alberta Science Centre. His book,* The Backyard Astronomer's Guide *contains several detailed chapters of astrophotography advice.*

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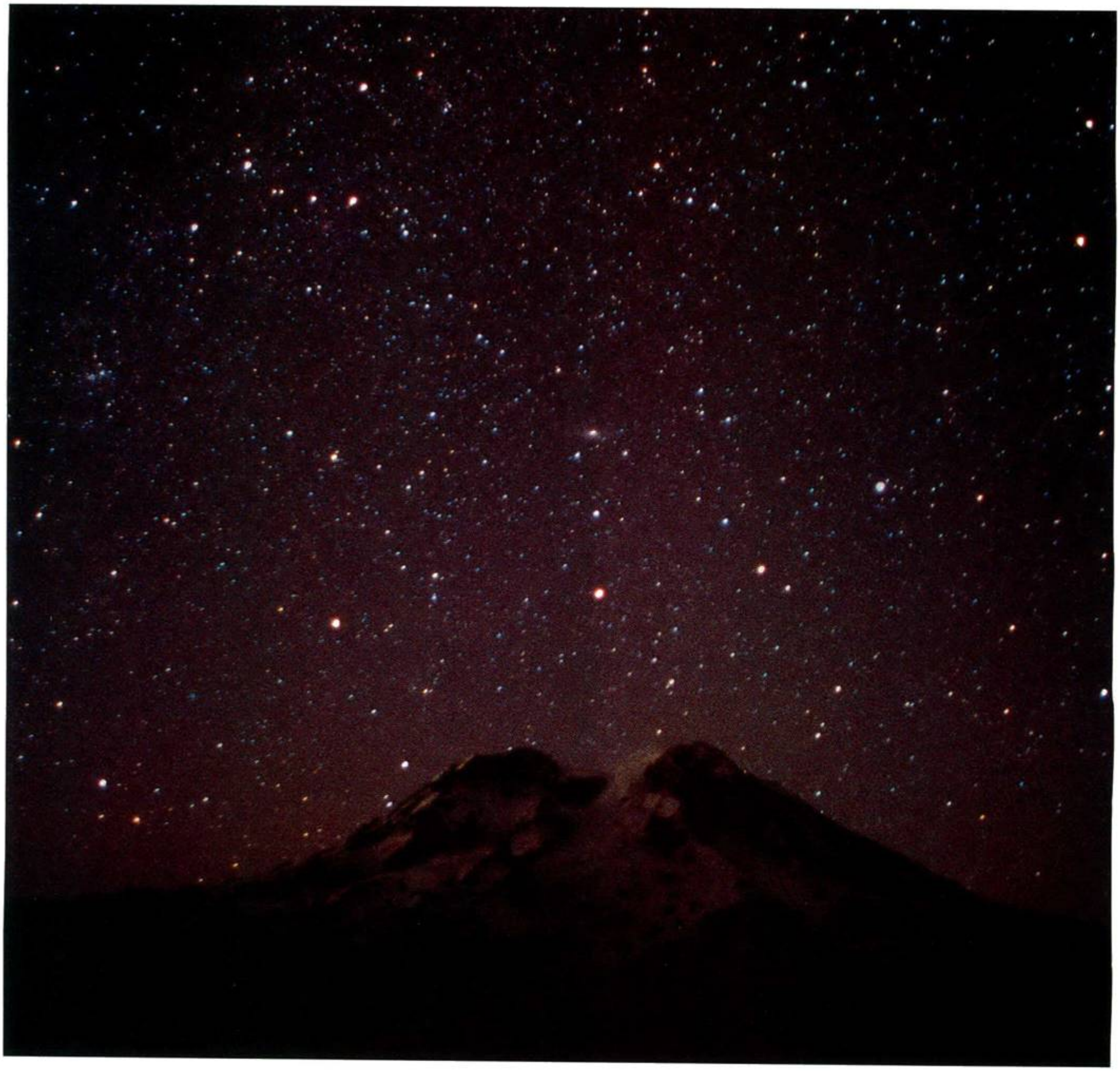
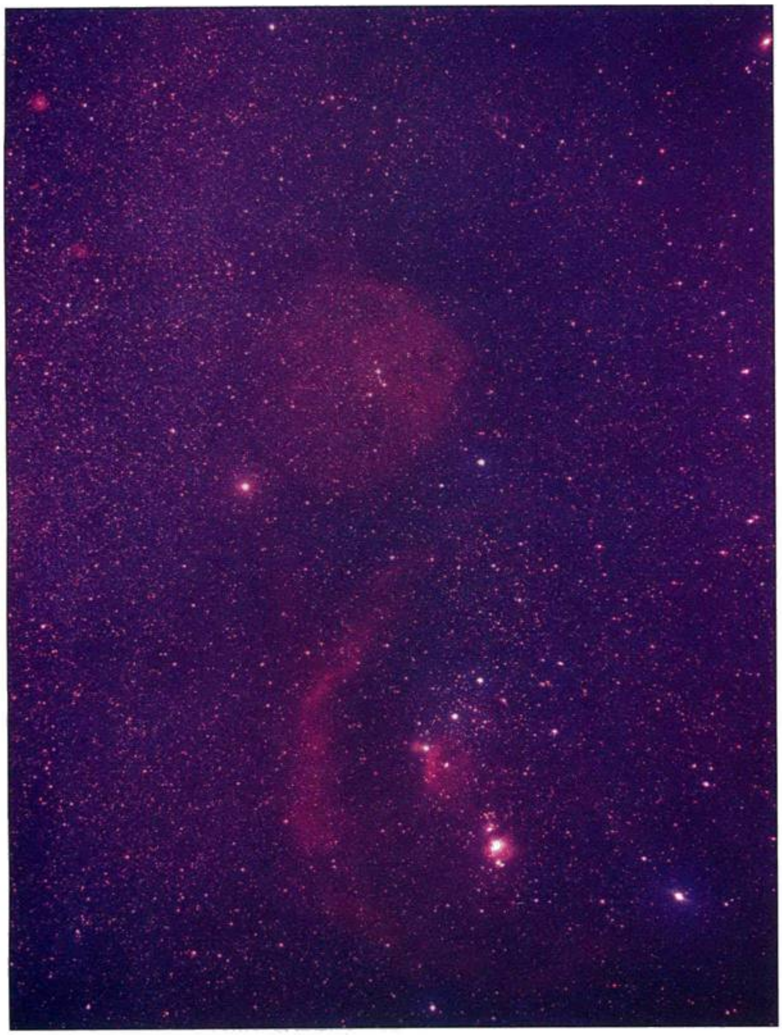
# THE BEAUTIFUL UNIVERSE

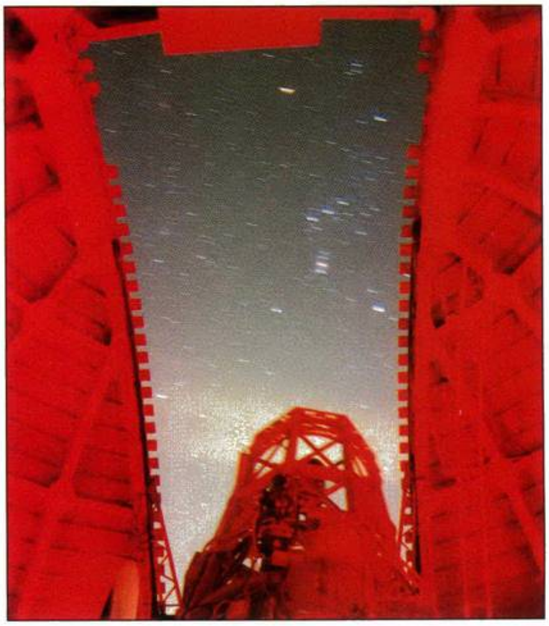
*A gallery of the year's best photographs from the readers of* ASTRONOMY.



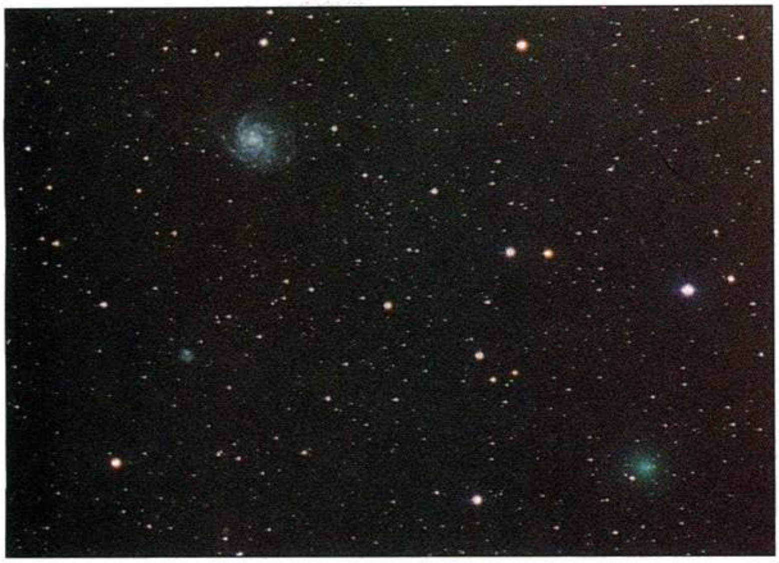
**Andromeda Rises over Mt. Ranier, Washington**
The faint glow of the Andromeda Galaxy, the Milky Way's sister spiral, lies at center
*Jerry Schad*
(24mm lens at f/4, P1600 film pushed to ISO 5000, 60-second exposure)



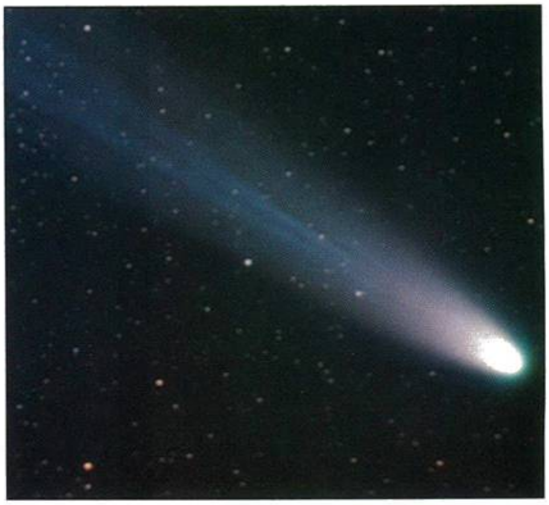
**Orion's Thick Blanket of Nebulosity**
It includes the Orion Nebula, Horsehead Nebula, Barnard's Loop, and Lambda Orionis Bubble
*Bob Gleich*
(50mm lens at f/2.8, Fuji HG 400 film, 30-minute exposure using a Deep-Sky filter)



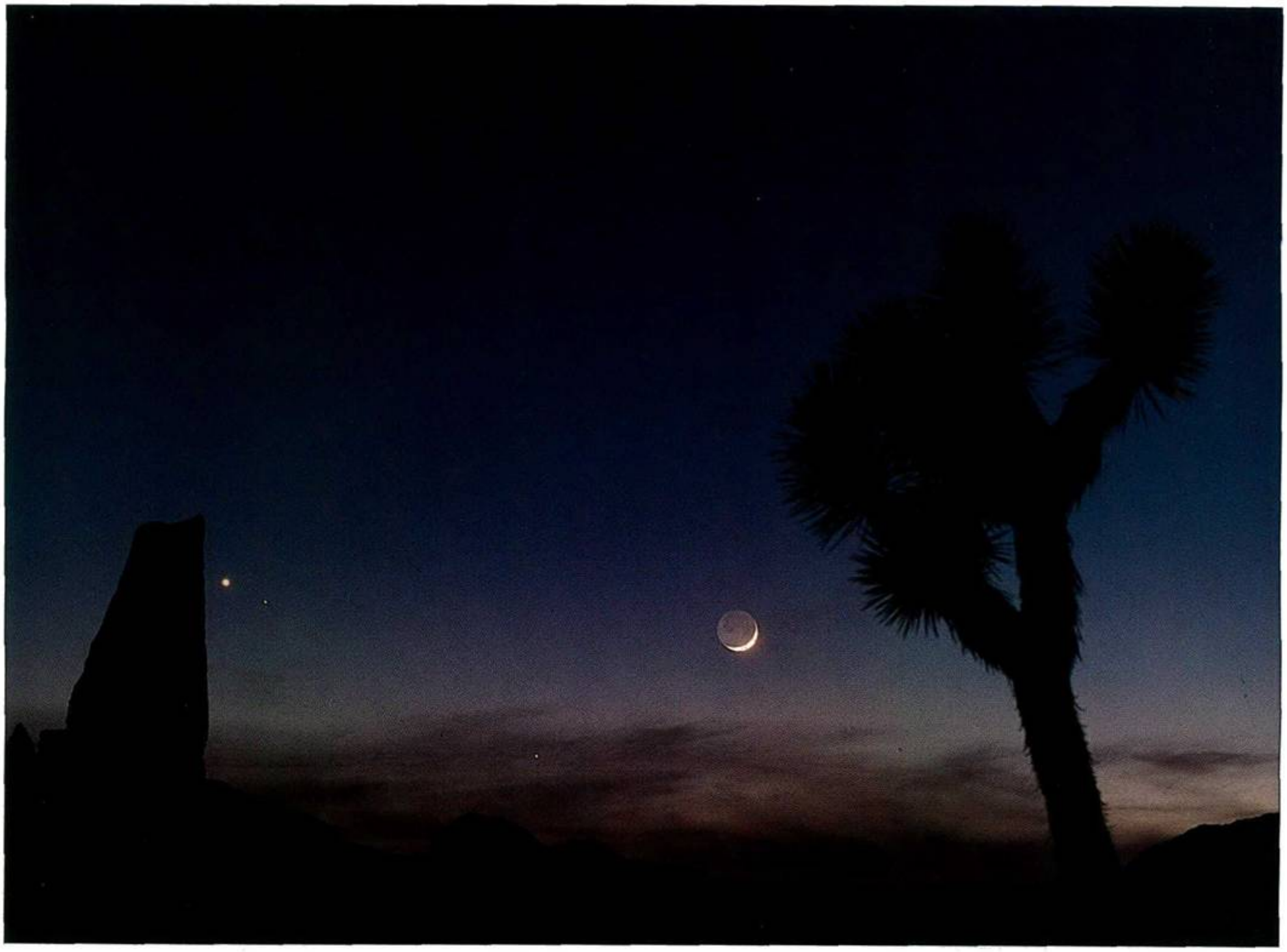
**Orion's Stars Trail Beyond the Slit of an Observatory**
Mount Wilson's 60-inch telescope, below, is one of this century's workhorses
*Dave Hasenauer*
(28mm lens at f/2.8, Kodak Gold 200 film, 5-minute exposure taken November 19, 1995)



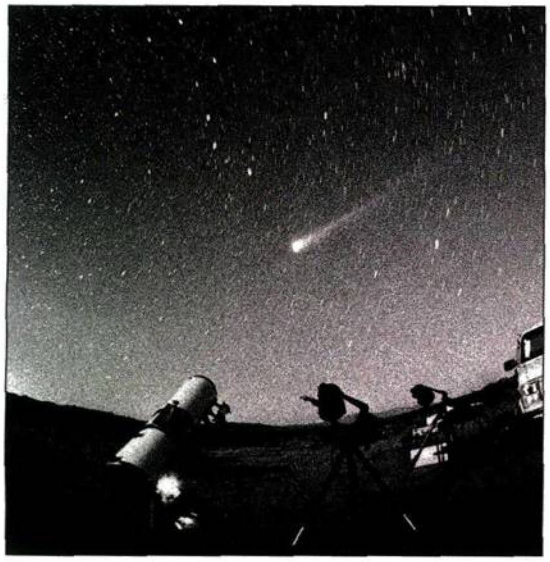
**Comet Szczepanski Pairs with Galaxy M101**
The comet, bottom right, reached 8th magnitude in a year remembered for another comet
*Gerald Rhemann and Franz Kersche*
(8-inch f/1.5 Schmidt camera, Kodak Gold 160 film, composite of two 6-minute exposures taken January 31, 1996)



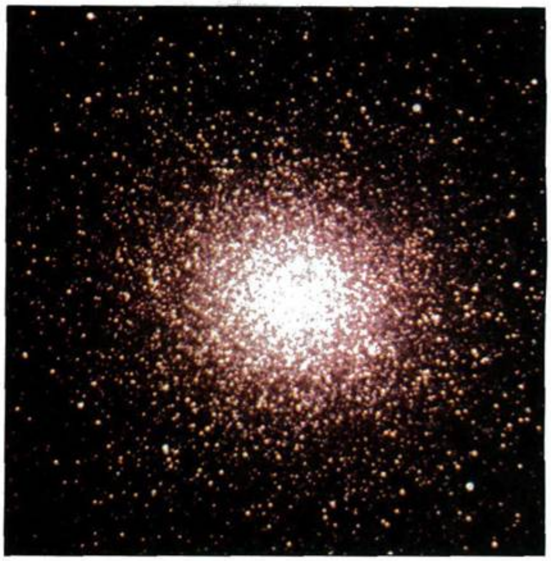
**The Beautiful Colors of Hyakutake's Tail**
Sharp, narrow streamers converge from parallel lines into the pinpoint inner coma
*Michael Stecker*
(5-inch f/6 refractor, Fujicolor Super G 800 Plus film, 18-minute exposure taken April 13, 1996)



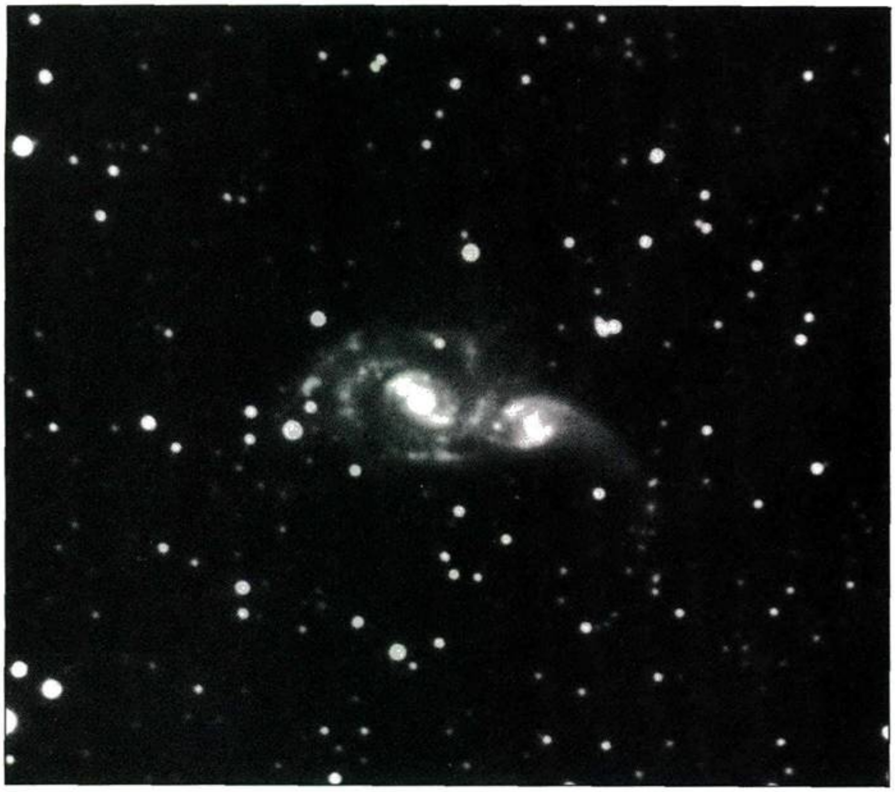
**Venus, Mars, Jupiter, and the Moon**
Three planets and our nearest celestial neighbor converge in the evening sky
*Ren Navez*
(80mm lens at f/8, Ektachrome 100 film, 9-second exposure taken November 25, 1995)



**Hyakutake Hovers over Joshua Tree National Monument**
Note the two faint meteors just over the third telescope from left
*Peter Hubert*
(16mm lens at f/2.8, TMZ 3200 film, 5-minute exposure taken March 23, 1996)

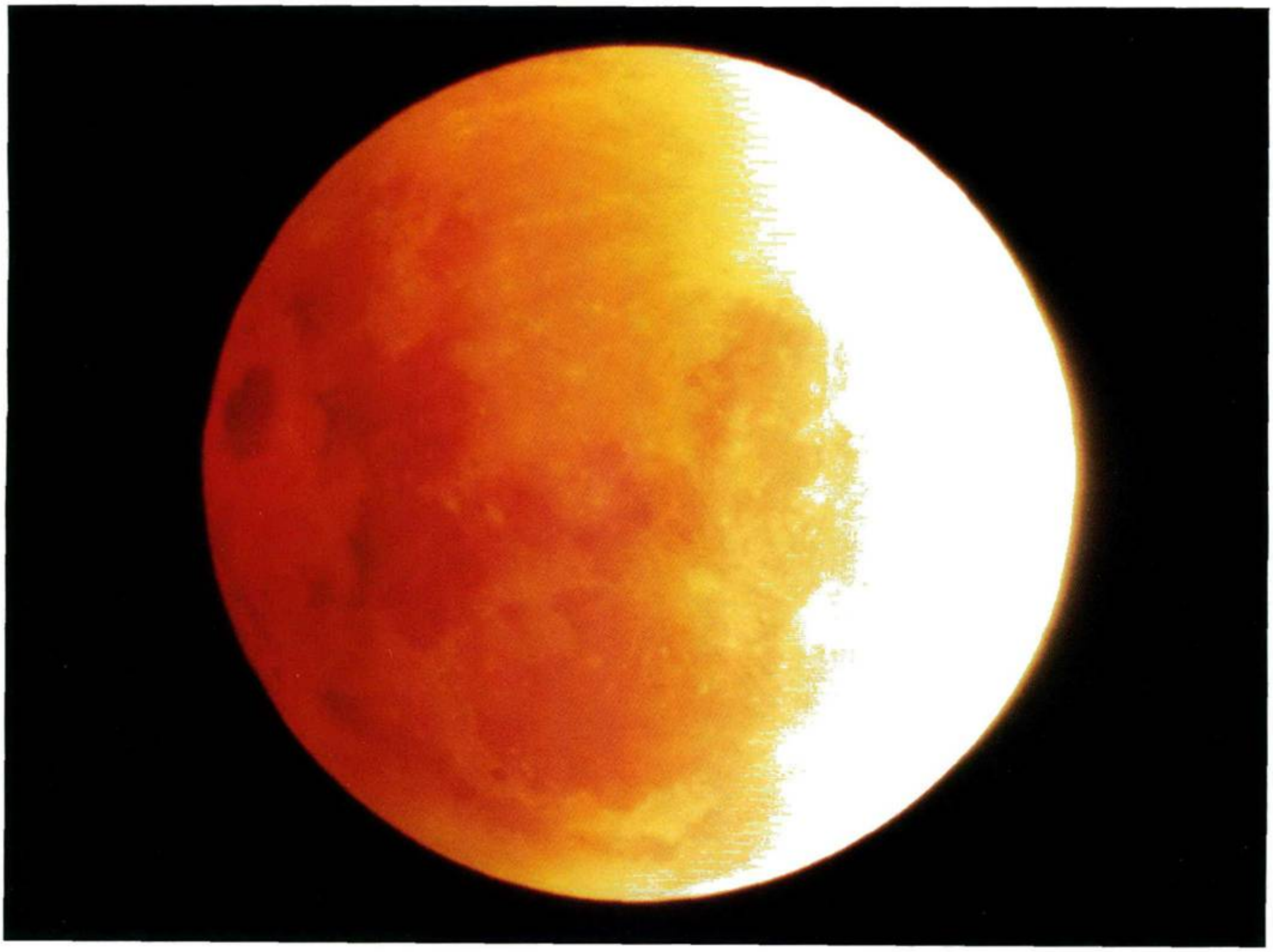


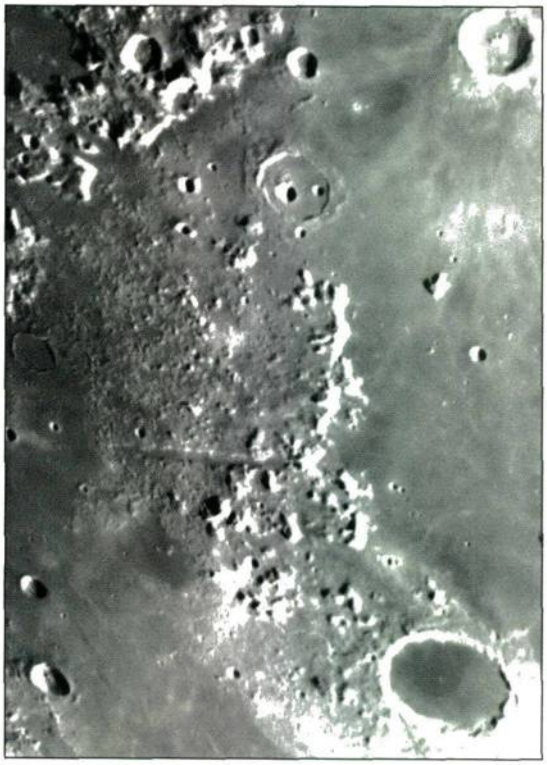
**Globular Star Cluster Omega Centauri**
A million aged stars swarm like bees in a disturbed hive
*Jason Ware*
(16-inch SCT, Fuji HG 400 film, composite of two 30-minute exposures)



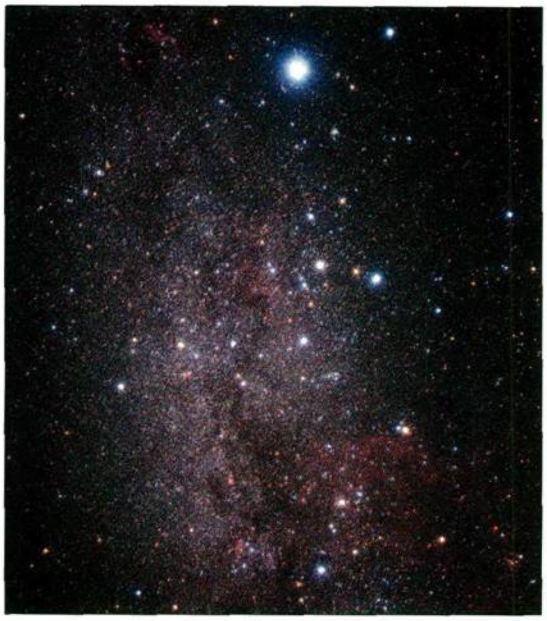
**Colliding Galaxies NGC 2207 and IC 2163 Dance in the Night**
At a distance of 110 million light-years, the galaxies' interactions are barely visible
*David Healy*
(14-inch SCT at f/7, hypered Tech Pan film, 80-minute exposure)

**The Lunar Eclipse of April 3/4, 1996**
Earth's shadow darkened the Moon as seen from the Americas, Europe, Africa, and western Asia
*Nicolas Rossow*
(Sensia 100 film, 90-second exposure taken April 3, 1996)

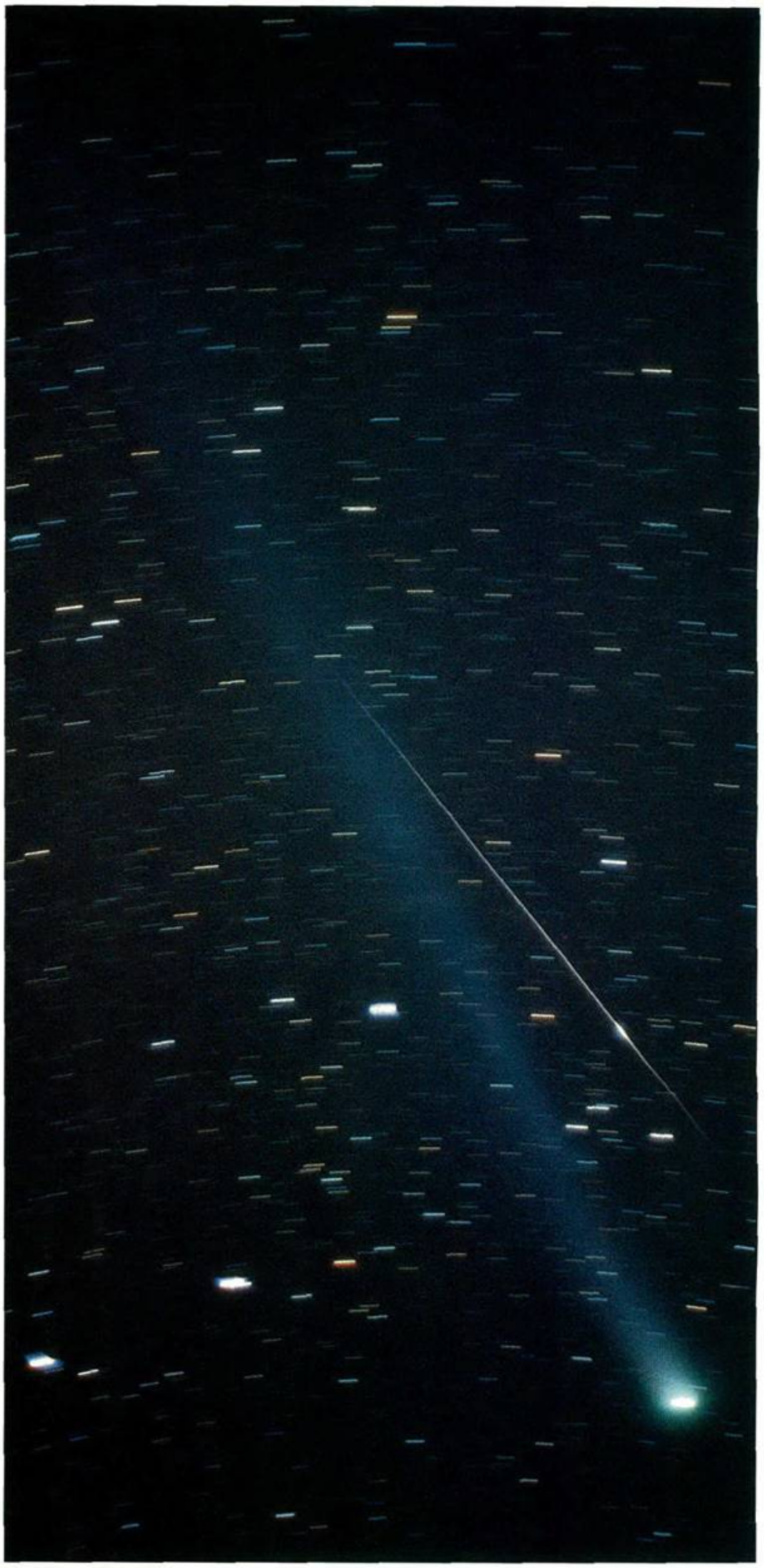




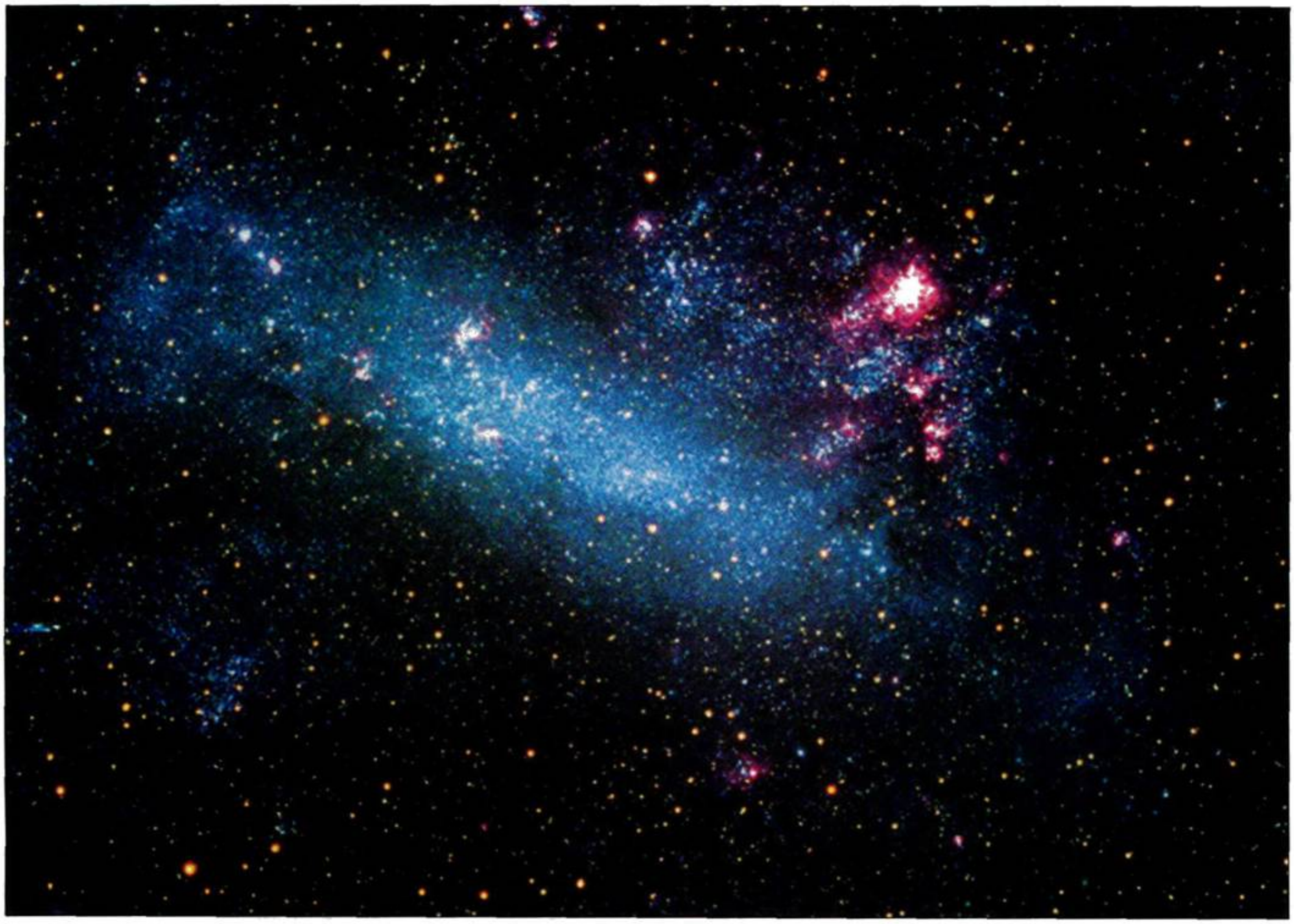
**The Moon's Alpine Valley**
This cleft in the Moon's floor stretches 180 km
*Cesar Descordes*
(9-inch Cassegrain, Tech Pan film, 1-second exposure taken October 14, 1995)

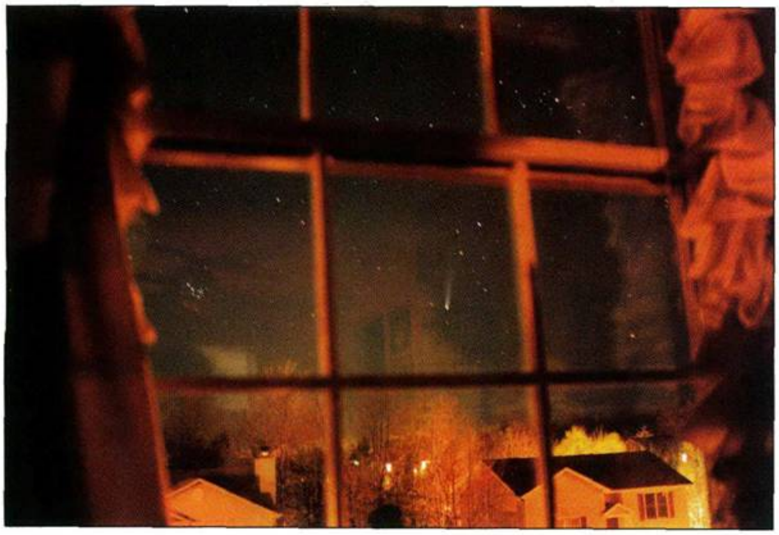


**Sparkling Stars of Canis Major and Puppis**
Numerous deep-sky targets are visible in the rich Milky Way
*Luke Dodd*
(55mm lens at f/4, hypered Fujicolor 400 film, composite of two 25-minute exposures)

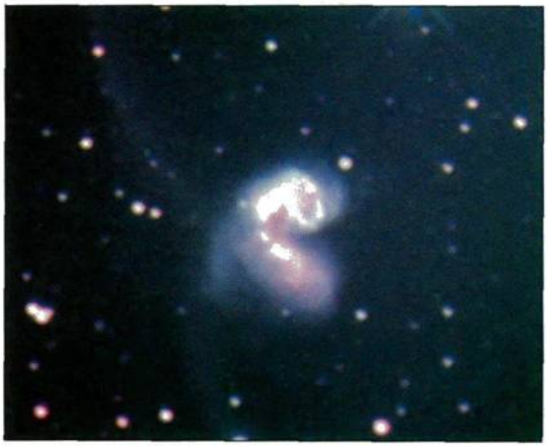


**A Bright Meteor Flashes Past Comet Hyakutake**
This sporadic flash resulted from a grain of debris that ionized in Earth's atmosphere
*Mark Riddick*
(50mm lens at f/1.2, Ektachrome 400 film, 2-minute exposure taken March 24, 1996)



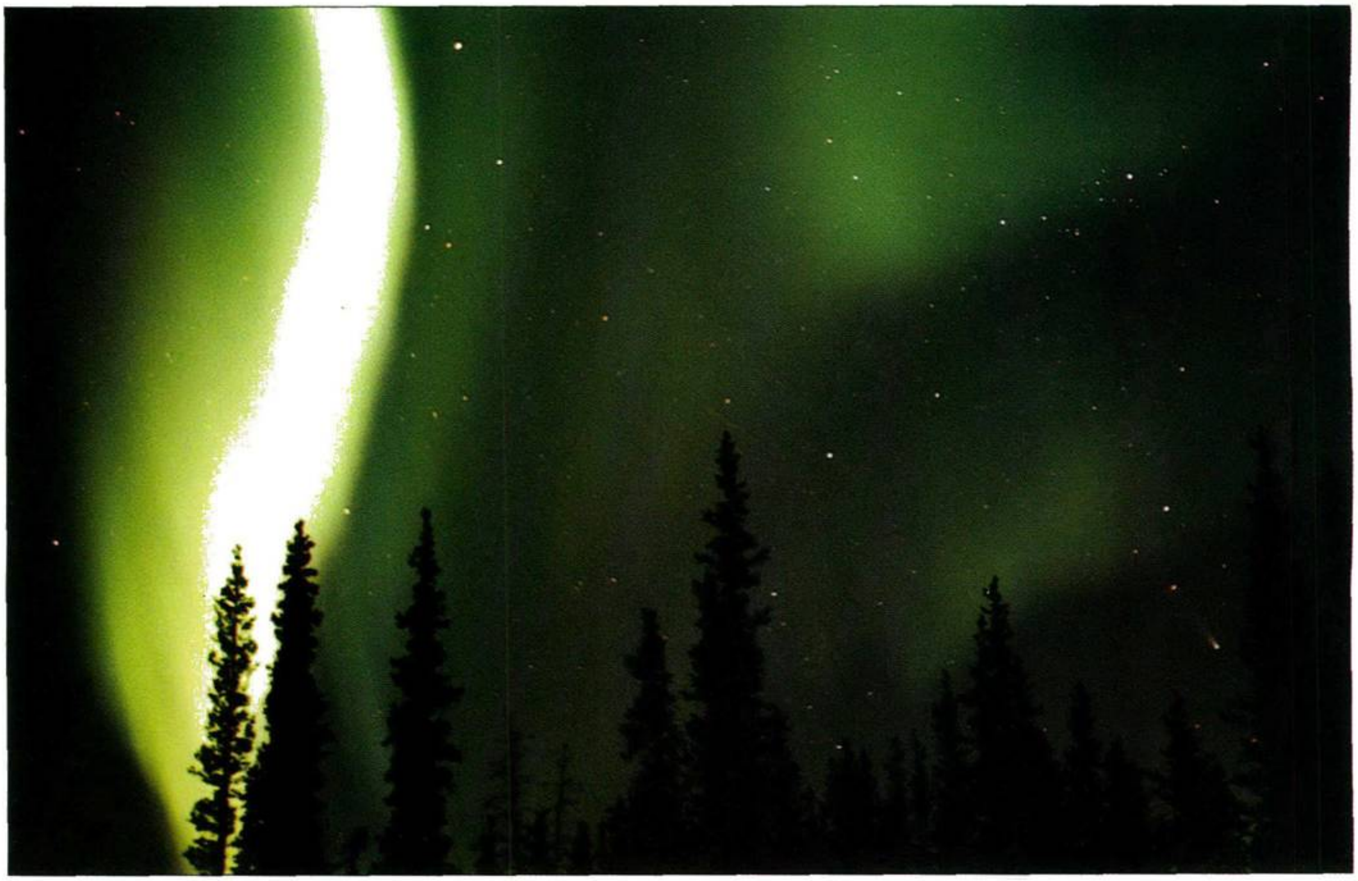


**The Large Magellanic Cloud**
A satellite galaxy of the Milky Way
*Bob Sandness*
(8-inch f/1.5 Schmidt camera, Fuji G800 film, 15-minute exposure)

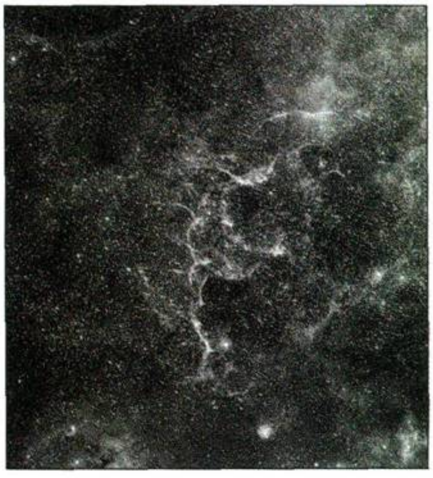


**The Living Room Comet**
Hyakutake was bright enough to observe from *indoors*, glass windows and all
*Myron E. Wasiuta*
(35mm lens at f/2.8, Fuji 800 G film, taken April 17, 1996)

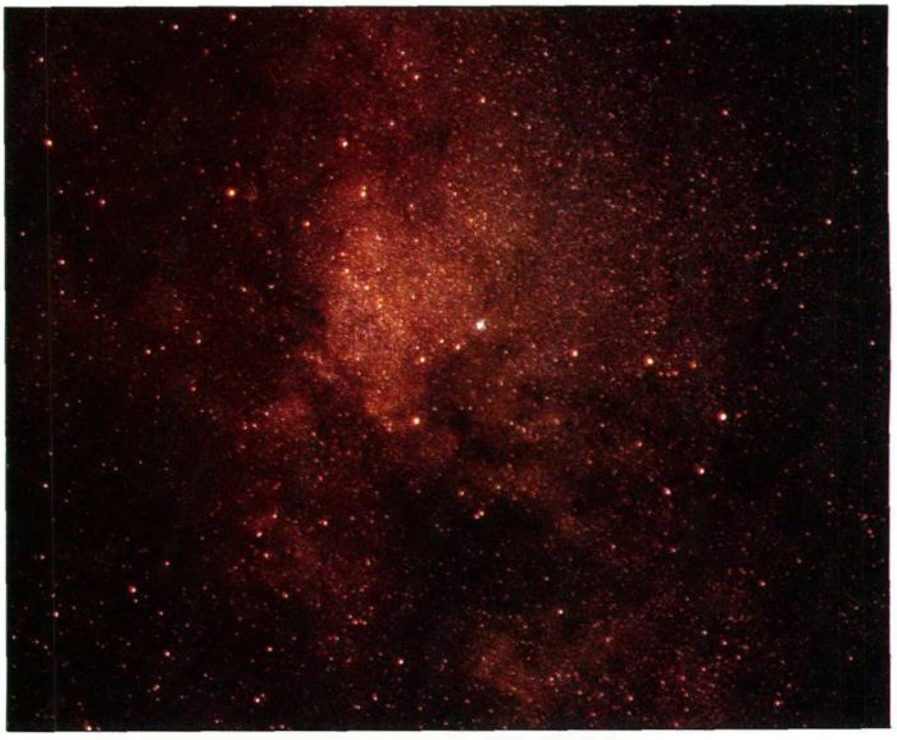
**The Ringtail Galaxy in Corvus**
NGC 4038 and NGC 4039, a highly distorted pair of galaxies on the merge
*Tim Hunter and James McGaha*
(24-inch f/5 reflector, HPC-1 CCD camera)



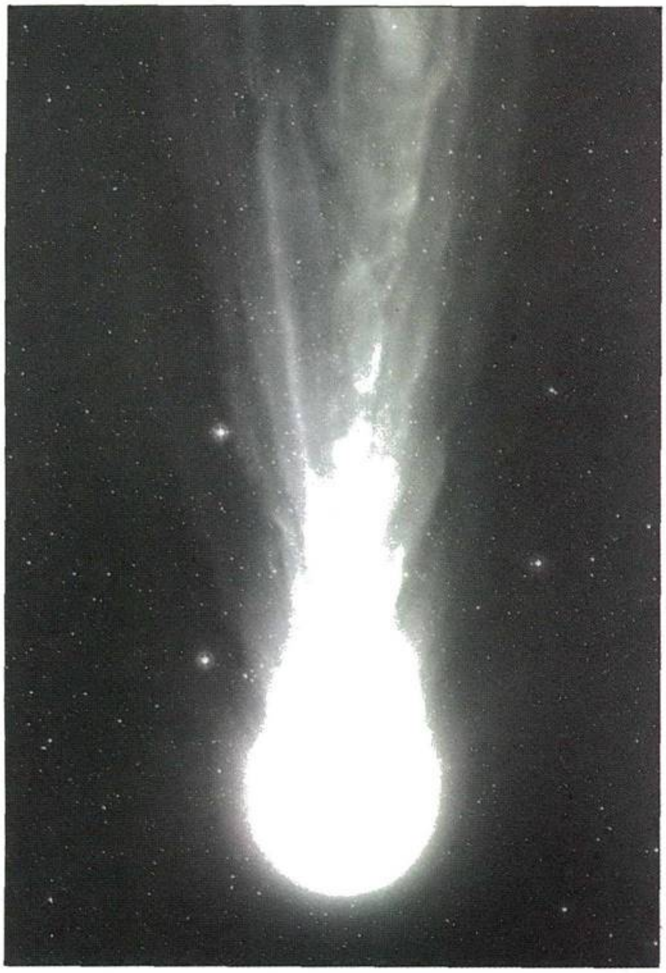
**A Brilliant Aurora Overshadows Comet Hyakutake**
The comet hangs precariously low at right, at the feet of Perseus
*Dave Cartier*
(24mm lens at f/2.8, Fuji 400 film, 22-second exposure taken April 17, 1996)



**The Vela Supernova Remnant**
The ghostly remains of an exploded star
*Michael Stecker*
(180mm lens at f/2.5, hypered Tech Pan film, 70-minute exposure using an Hα filter)



**The Scutum Starcloud**
The Wild Duck Cluster (M11) is the bright clump of white stars near center
*Giovanni Andreis*
(105mm lens at f/4, Kodak EP 1600 film, 10-minute exposure)



**Ropelike Structures in Hyakutake's Tail**

*The variety of intricate features in the comet's ion tail delighted backyard observers*

*Bob Yen*

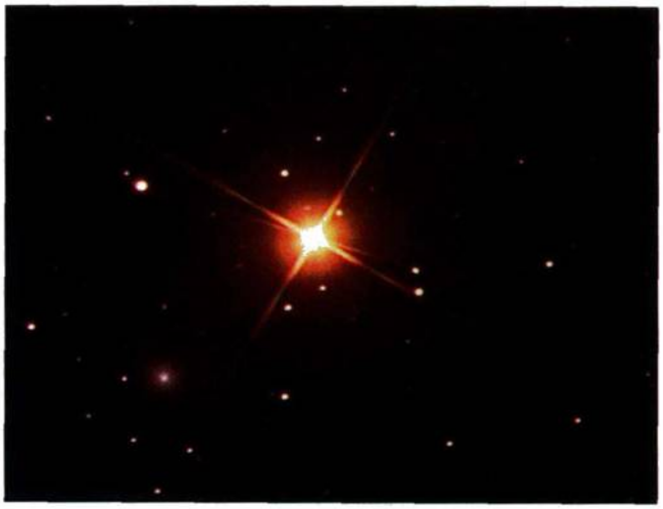
(8-inch f/1.5 Schmidt camera, hypered Tech Pan film, 4-minute exposure taken March 22, 1996)

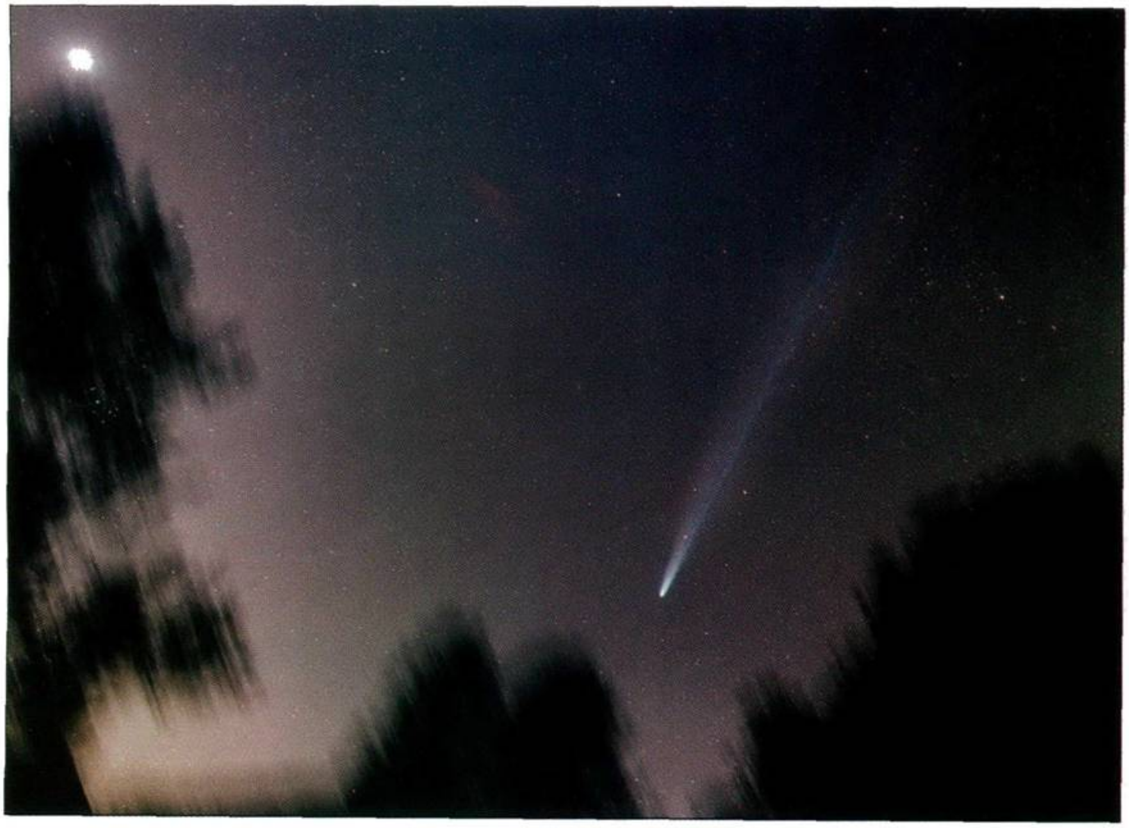
**Elliptical Galaxy NGC 404 and Bright Star Beta Andromedae**

This nearby dwarf galaxy can be hard to spot because of the bright star's glare

*John Chumack*

(16-inch f/4.5 reflector, Kodak Gold 400 film, 15-minute exposure)



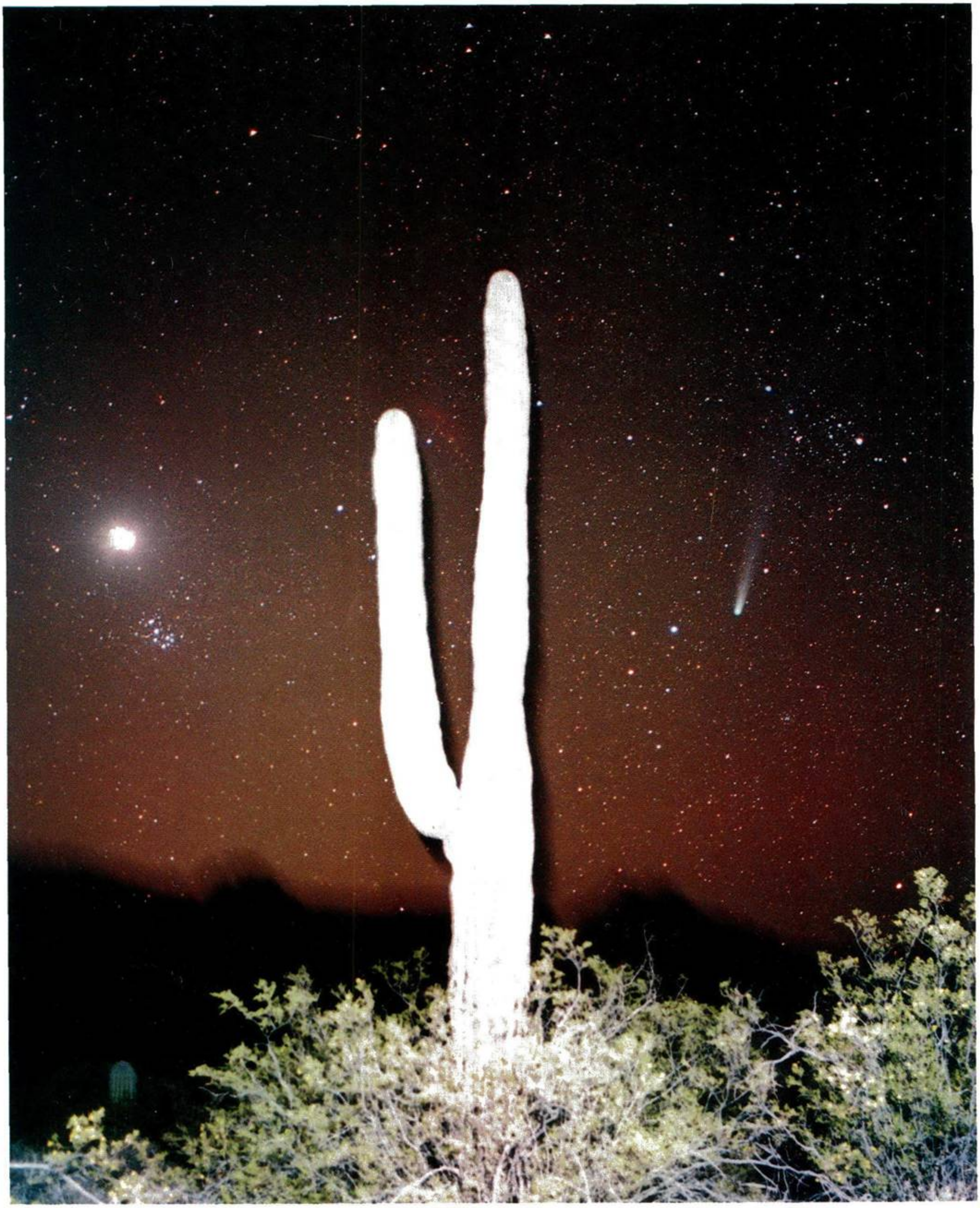


**Comet Hyakutake with Venus**

Also visible are the California Nebula and the Pleiades

*John A. Volk*

(105mm lens at f/3, hypered Konica Super XG400 film, taken April 13, 1996)

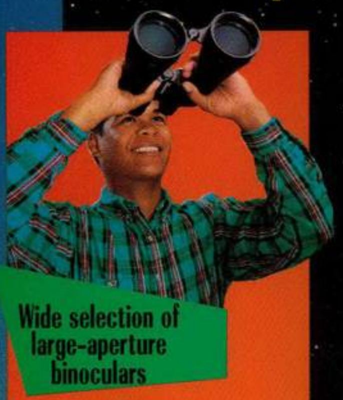


**Comet Hyakutake,Venus, and the Pleiades**

*Bob Yen*

(35mm lens at f/2, Fuji 800 film, 6-minute exposure taken April 7, 1996 from Organ Pipe National Monument, Arizona; foreground illuminated at end of exposure with a strobe flash)

# Any Way You Look At It...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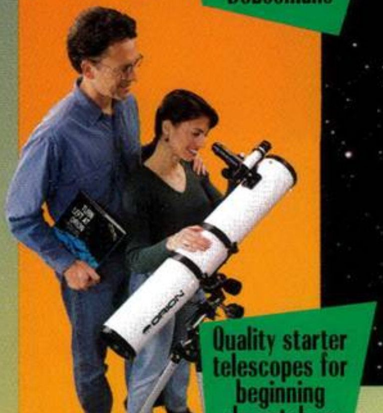
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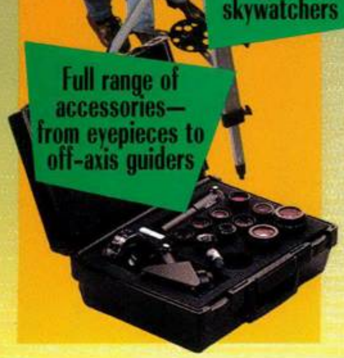
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Comet Hyakutake photo: Steve Mandel

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